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RELIABILITY ENHANCEMENT OF THE NAVY METROLOGY AND CALIBRATION PROGRAM

by

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Three quarters of the Naval Air Systems Command Metrology and Calibration (METCAL) budget is spent on Support Equipment with calibration intervals that are 12 months or less. These intervals are based on End-of-Period (EOP) operational reliability targets of 72% for non-critical General Purpose Test Equipment (GPTE) and 85% for critical Special Purpose Test Equipment (SPTE). Over one-third of all Support Equipment are performing above their reliability targets, but are unnecessarily being inducted into calibration facilities due to maximum interval restrictions. With continued budget constraints, the Navy will be forced to adopt innovative measures to save costs, while not sacrificing readiness or safety. Based on our analysis, we conclude that by increasing the reliability targets, and interval restrictions, we will save the Navy over $1.2 million per year with a concomitant increase in the reliability of 46% of Naval Aviation's TAMS by 9.71%.

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RELIABILITY ENHANCEMENT OF THE NAVY METROLOGY AND CALIBRATION PROGRAM

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ABSTRACT

Three quarters of the Naval Air Systems Command Metrology and Calibration (METCAL) budget is spent on Support Equipment with calibration intervals that are 12 months or less. These intervals are based on End-of-Period (EOP) operational reliability targets of 72% for non-critical General Purpose Test Equipment (GPTE) and 85% for critical Special Purpose Test Equipment (SPTE). Over one-third of all Support Equipment are performing above their reliability targets, but are unnecessarily being inducted into calibration facilities due to maximum interval restrictions. With continued budget constraints, the Navy will be forced to adopt innovative measures to save costs, while not sacrificing readiness or safety. Based on our analysis, we conclude that by increasing the reliability targets, and interval restrictions, we will save the Navy over $1.2 million per year with a concomitant increase in the reliability of 46% of Naval Aviation's TAMS by 9.71%.

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I. INTRODUCTION

A. BACKGROUND

The availability and safe operations of today's weapons systems can be directly attributed to the quality of the Test and Monitoring Systems (TAMS) that support them. Reduced budgets have increased the pressure for logisticians to develop even more innovative ways to reengineer current processes in order to maintain or improve readiness goals. The Metrology and Calibration (METCAL) Program that manages TAMS is a key program in Naval Aviation Maintenance that can be made more efficient and provide significant cost savings.

Type Commanders (TYCOMS) and the Naval Air Systems Command (NAVAIR) METCAL Program office currently spend over three-quarters of their calibration man-hour budgets on Support Equipment(SE) with calibration intervals that are 12 months or less (Dwyer, 1992). This equates to an expenditure of over $27 million a year for only 30 percent of the items in inventory. Figure 1 amplifies the hyperbolic relationship between calibration intervals and yearly budget expenditures. Figure 2 shows the annual

expenditure on the top-ten items of TAMS in the NAVAIR inventory. This data suggests the costs are associated with the failure to adequately invest in reliability and maintainability early in the development of a system.

Since there has been marginal success in previous attempts to improve reliability in existing weapons systems, through hardware/software upgrades (COMNAVAIRSYSCOM, 1983), in our research we will focus on augmenting reliability improvements through changes in METCAL policy.

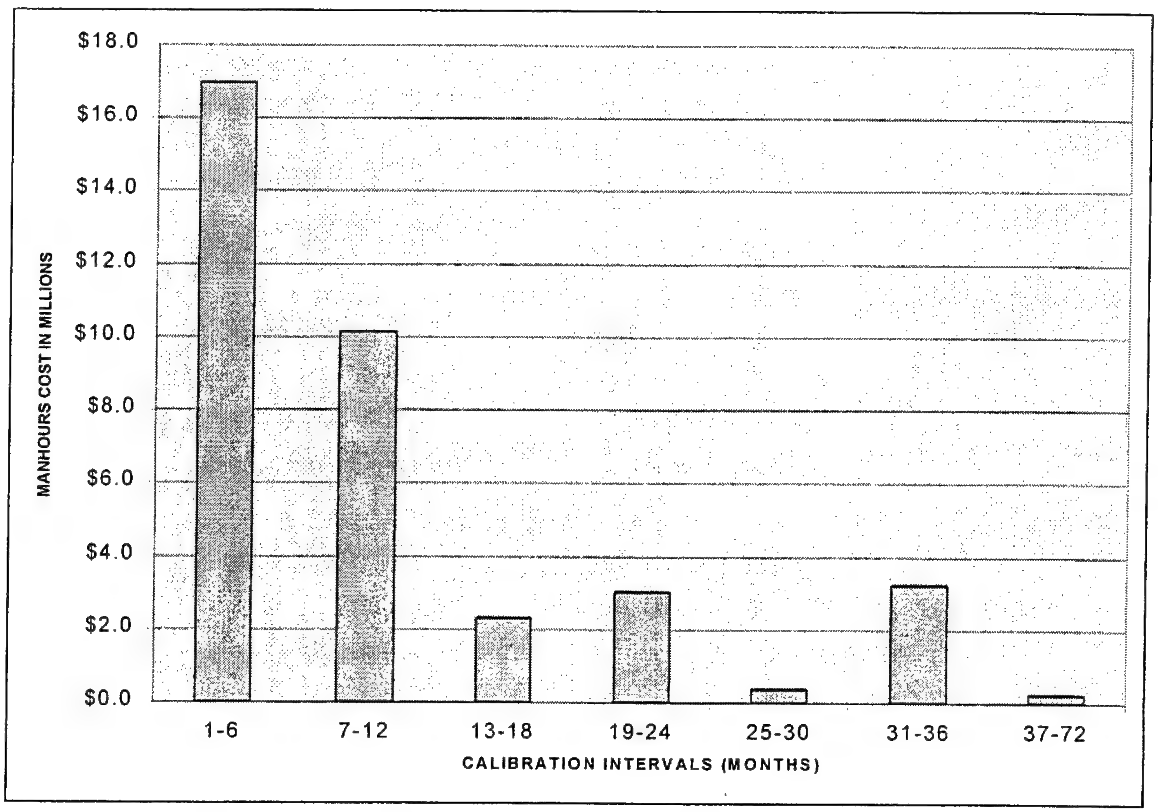

Figure 1. Annual NAVAIR METCAL Expenditures by Calibration Interval

MODEL	NOMENCLATURE	INTRVL MONTHS	ITEMS	MH's/ YR	COST/YR
178AS100	AIRCRAFT FIRING CIRCUIT T/S	9	288	1,901	$76,032
ANUSM470V1	AVIONICS T/S	8	39	1,907	$76,284
281069	POWER EQUIP ANALYZER	5	150	1,933	$77,328
3000B	SERVICE MONITOR	6	273	1,938	$77,532
ANAPM424V2	IFF TRANSPONDER T/S	7	178	2,667	$106,678
155600	IFF TRANSPONDER T/S	7	186	2,787	$111,472
TF20-1A	LIQ QUANTITY SYS T/S	2	185	3,430	$137,196
PPTS101	PULSE POWER T/S	4	121	4,211	$168,432
ANAWM54	AIRCRAFT FIRING CIRCUIT T/S	9	748	4,937	$197,472
ANAPM378	TRANSPONDER T/S	4	322	5,796	$231,840
			TOTAL COST:		$1,260,266

Figure 2. Top-Ten Expenditure Items of TAMS

Presently, reliability targets are established between COMNAVAIRSYSCOM and NWAD to represent TAMS reliability after consideration of mission/use, logistics, economic, and safety considerations (NAVAIR 17-35TR-1, 1983). Reliability of TAMS is defined as the probability that a piece of equipment will function properly over a specified period of time. There are three categories of TAMS in the METCAL Program, General Purpose Test Equipment (GPTE), Special Purpose Test Equipment (SPTE) and Automated Test Equipment (ATE).

1. General Purpose Test Equipment (GPTE)

GPTE is that set of equipment which is in common use to support two or more operational systems or equipment of basically different design. In general, GPTE is calibrated at an authorized calibration facility to manufacturer's specifications. Examples of GPTE are recorders, leak detectors, and hardness testers. GPTE calibration intervals are calculated to meet an End-of-Period reliability target of 72% or an Average Over-the-Period target of 85%.

2. Special Purpose Test Equipment (SPTE)

SPTE is that set of equipment which is used for a unique application such as support of a single or peculiar operational system or equipment. In general, SPTE is calibrated by an authorized calibration facility to specifications derived from the actual use requirements. SPTE calibration intervals are calculated to meet an End-of-Period reliability target of 85% or an Average Over-the-Period target of 92%.

3. Automated Test Equipment (ATE)

ATE is that set of equipment wherein the testing process is under some form of preprogrammed control, where

the test steps, equipment set-ups and tolerance decisions are embedded into a computer or microprocessor rather than in a technical manual. With ATE, the operator generally establishes the initial test set-up, prescribes the test process, initiates the test, and performs selected actions based on test results and decisions provided for by the automated TAMS. ATE is often a combination of GPTE and SPTE. The calibration of ATE has undergone many changes over the years and various calibration approaches have been utilized. Currently, ATE is calibrated as an integral system.

Embedded Test and Monitoring Capabilities (ETMC) is that set of test and monitoring capabilities which are considered to be an integral part of an operational system or equipment. ETMC is generally considered to be of two types: Built-In Test (BIT) and Built-In Test Equipment (BITE). BIT is normally an integral part of the operational system or equipment where removal would impair the operation of the system. BITE, on the other hand, is an easily identifiable entity and removal from the system or equipment can be accomplished without impairing the operation of the

system. In general, ETMC requires calibration if it is the principal means for quantitatively assessing the performance, readiness, condition or state of an operational system or equipment. ETMC is calibrated to specifications derived from the actual use requirement by either on-site personnel or an authorized calibration facility. Investment in ETMC, when developing new systems, provides an excellent opportunity to reduce life cycle costs.

The Navy has employed the exponential probability distribution failure model since 1971 to describe the measurement reliability of TAMS as a function of calibration interval. Figure 3 shows the models and elements for EOP and AOP respectively. EOP is defined as the probability that at the end of an item's calibration cycle, a certain number out of 100 would still be within tolerance. AOP is defined as the probability that at an instantaneous time during the calibration cycle, a certain number of common family items would be expected to be within tolerance. The target reliabilities used by the Navy are based on a compromise between cost, logistic constraints and loss of utility for equipment used in an out-of-tolerance state.

The reliability targets have been set to meet these constraints in a manner acceptable to the Commands that are supported by the Naval Warfare Assessment Division (NWAD).

$$R_{eop} = e^{-\lambda\tau}$$

$$R_{aop} = e^{-\lambda\tau/2}$$

R_{eop} - End of Period Reliability

R_{aop} - Average Over-the-Period Reliability

e - 2.71828

λ - Out-of-tolerance rate expressed in out-of-tolerance conditions occurring per month for a single item

τ - Time since last calibration

Figure 3. Exponential Distribution Probability Model (Dwyer, 1997)

Over one-third of all test equipment is currently at its maximum interval (Dwyer, 1992). The vast majority of these items are performing above their established reliability targets, but are still required to be inducted into calibration facilities at the end of their maximum

interval. Figure 4 more closely examines the significant spikes at the 19-24 and 31-36 month intervals that were shown in Figure 1. It graphically shows the budget impact of interval limits that are placed at the 24 and 36 month calibration cycles. This interval "restriction" prevents the optimization of the METCAL Program. This "restriction" forces the Navy to spend hundreds of thousands of maintenance dollars on TAMS that are not in need of calibration. Additionally, with the current consolidation of calibration laboratories, even greater savings could be found in reduced transportation costs.

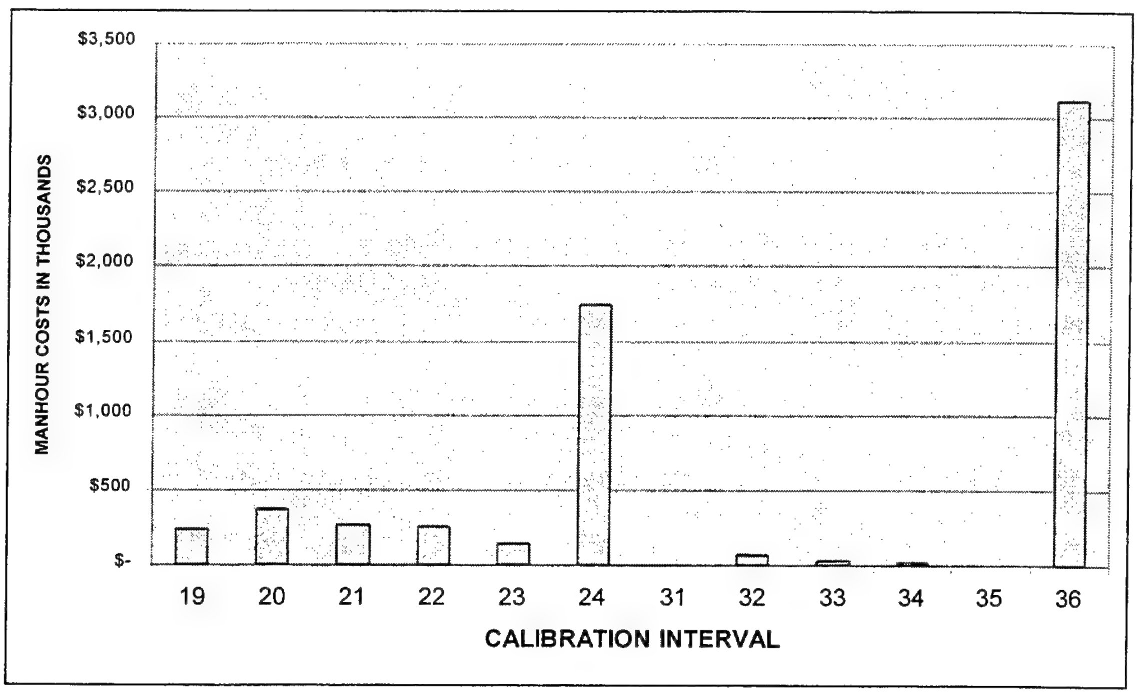

Figure 4. Breakdown of 19-24 and 31-36 Month Intervals

Maximum allowable calibration intervals are assigned to equipment categories as shown in Appendix B. These maximum values are determined to be the longest feasible calibration intervals for equipment typical to these categories. For categories where no specific maximum calibration interval has been established, the maximum interval defaults to 36 months.

There are three secondary effects that are directly correlated to the METCAL Program: safety, maintenance costs, and readiness.

4. Safety

In researching the risks associated with TAMS reliability, the author worked with analysts from the Naval Safety Center in an attempt to find any correlation between aviation mishaps and support equipment. The results of multiple database queries showed no correlation (Dimaano, 1997). There is no record of any item of TAMS being directly or indirectly attributable to an aircraft mishap. This may be misleading due to the fact that TAMS are not sent in for testing, to determine if they are still within calibration standards, after an aircraft mishap. The

accident investigation team only goes as far as verifying that TAMS are not overdue for calibration (Goldfinger, 1997). New light has been shed on safety since the mishap over northern Iraq, in which two Army Blackhawk helicopters were shot down by Air Force F-15's. Contributing factors in this mishap were problems with the APX-100 Interrogation Friend or Foe (IFF) audio light-out and antenna diversity switches. Three of the top-ten items listed in Figure 2 are used to maintain IFF systems. Catastrophic events such as this are the reason commercial airlines utilize higher reliability goals and shorter calibration cycles. Under Federal Aviation Regulations, Part 145; commercial repair stations are required to calibrate their TAMS on a "regular interval" in accordance with the National Bureau of Standards. The Federal Aviation Administrations interpretation of a "regular interval" is, a maximum interval of 12 months, with shortened intervals for items used in adverse environments (Freydoz, 1997). There is a great contrast between the commercial sector and the military. There are over 300,000 items of TAMS that fall under the NAVAIR METCAL Program, compared to a commercial

average of about 20,000 per airline (Skinner, 1997). By sheer number, the Navy is forced to utilize a different approach. It would be physically and financial impossible to calibrate all 300,000 items each year. Another contrast is the cost of a mishap for a commercial airline compared to the military. The Value Jet crash in 1996 led to a complete collapse of the company. In Fiscal Year 1996, Naval Aviation had 36 Class "A" mishaps, at a cost of over $805 million dollar and 46 lives (Goldfinger, 1997). Although there is little threat of shutting down Naval Aviation, there is the tremendous loss in aircraft and personnel.

Even though there is no statistical data to correlate mishaps to the calibration of TAMS, it is intuitive that the quality and safety of today's weapons systems lies directly upon the quality of the TAMS that support them.

5. Maintenance Costs

The DoD has instituted new policies that greatly increase the cost of incorrectly diagnosing failures at the Weapons System Repairable Assembly (WRA) or Shop Replaceable Assembly (SRA). Under the Working Capitol Fund (WCF), commands are charged the total cost of the item, even if it

is found to have no-defect when tested by the repairing activity (malfunction coded A799).

There is also an effort to increase the number of items repaired at a depot and reduce the repairs at the intermediate level. Under the new concept, SRA's are removed at the organizational-level and shipped directly to the Naval Aviation Depot (NADEP) or Original Equipment Manufacturer for repair. Again, the total cost of the item is charged, regardless of whether or not it is found to have a defect.

The Naval Air Logistics Database (NALDA) currently tracks maintenance actions that were unable to identify a defect (A799), but does not directly associate the maintenance action with a specific failure in fault isolation. In 1996, Navy organizational- and intermediate-level maintenance activities reported 155,418 A799's (Lout, 1997). An increase in the reliability of TAMS would most likely reduce that number.

6. Readiness

Reductions in spares and Just-In-Time (JIT) logistics, which attempts to maintain only the minimum inventory

necessary to keep a perfect system running, make accurate troubleshooting paramount. The Navy cannot afford to incorrectly tie-up valuable resources in the supply chain. The reliability of TAMS is more important than ever in ensuring that maintenance technicians correctly diagnose problems with the equipment that they supporting. A weakness in TAMS will result in tremendous backlogs at the repair facilities, and a subsequent drop in fleet readiness.

The initiative to modify the current mode of operation originates from the tremendous potential to reduce cost while maintaining or even improving readiness levels. However, the complexity and risk of modifying an aviation maintenance policy that has been in effect for almost three decades has limited the growth and change in this area. The risk of implementing changes of significant magnitude, as discussed above, can be minimized and measured through the use of comparative spreadsheet analysis.

Using spreadsheet analysis, we can partially assess the merit of changes to intervals and reliability targets without having to actually modify the 300,000 items that currently fall under the METCAL Program. To combat the

risks of modifying maintenance policy, analyses like these have proved to be an effective tool for evaluating the impact of these changes.

In this thesis, we evaluate the impact of changing the reliability targets from 85% to 90% EOP for SPTE and 72% to 85% EOP for GPTE. These changes only apply to items with intervals greater than 24 months and less than or equal to 48 months. The changes in reliability are coupled with the extension of the maximum interval restriction, for items at the 24 and 36 month limit, to a new limit of 48 months.

B. THESIS ORGANIZATION

This thesis is organized as follows. Chapter II provides background on the METCAL Program. Chapter III provides a detailed breakdown of the analyses development and methodology. Chapter IV examines the results of the analyses and Chapter V contains conclusions, recommendations and final remarks.

II. THE NAVAL METROLOGY AND CALIBRATION PROGRAM (METCAL)

A. DEFINITION

Metrology is the science of measurement or determination of conformance to technical requirements, including the development of standards and systems for absolute and relative measurements. Calibration is the process by which calibration installations compare a calibration standard, precision measuring equipment (PME), or Test and Monitoring Systems (TAMS) with a standard of higher accuracy to ensure the former is within specified limits (OPNAV 4790.2F, 1995). The primary objective of the METCAL Program is to accomplish the calibration and incidental repair of PME/TAMS used for organizational- and intermediate-level maintenance functions by the operating forces.

A calibration facility is an installation that provides calibration services for PME, TAMS, and calibration standards used by activities engaged in research, development, test and evaluation, production, quality assurance, maintenance, supply, and operation of weapon

systems, equipment and other DoD material. PME/TAMS used for quantitative measurement in the Navy METCAL Program, including calibration standards, must be periodically calibrated to be within specified accuracy limits required by supported systems and equipment.

Calibration laboratories are classified as Type I, II, III, or IV. Calibration laboratory type is determined by the accuracy level of calibration standards maintained and employed in the calibration or repair of equipment. For example, if a Type IV lab had a standard for the inch, the Type II standard would be accurate to 0.10 inch, the Type II standard would be accurate to 0.01 inch, and the master inch at the Primary Standards Lab (Type I) would have an accuracy of 0.001 inch.

B. PROGRAM MANAGEMENT AND IMPLEMENTATION

Metrology and calibration is budgeted, funded, and managed as a subprogram under the depot-level Aircraft Support Services Program. The Metrology Automated System for Uniform Recall and Reporting (MEASURE) provides management information and data required to execute the

Commander Naval Aviation Systems Command (COMNAVAIRSYSCOM) METCAL Program.

The recall of equipment for calibration, at established intervals, is facilitated by the MEASURE. Naval Aviation Depot Operations Center (NAVAVNDEPOTOPSCEN) publishes and monitors equipment recall schedules, and allocates resources required to execute the schedules. These schedules determine workload composition, authorizing MEASURE customers to forward specific equipment to the laboratories indicated for calibration.

Equipment scheduled into a laboratory for calibration and servicing is based on calibration intervals established by the Naval Warfare Assessment Division (NWAD), the Metrology Requirements list (NA 17-35MTL-1), and the number of active metrology standards in the inventory at the various Type IV laboratories. NWAD also provides engineering inquiries and actions, approved calibration standards and procedures, technical criteria and management documents and also conducts annual audits of calibration laboratories.

III. DEVELOPMENT OF THE MODEL

A. THE POWER OF SPREADSHEETS

1. Spreadsheets

Spreadsheets have become a highly valuable decision support tool for managers to evaluate proposed changes to programs. Vazsonyi (1993) provided a journal article that details the power and potential of spreadsheets for today's manager. Spreadsheets provide a vehicle for managers to avoid classical mathematics and approximate solutions to their problems through elementary numerical analysis. For example, Kang (1993) developed a spreadsheet based decision support model that can evaluate fleet readiness under various logistics support scenarios, particularly in spare parts management.

In this thesis we utilize Microsoft Excel spreadsheets to develop models for comparative analysis and graphical displays. The desktop spreadsheet tool provides a medium to evaluate measures of effectiveness for the proposed changes to reliability targets and interval restrictions. The areas

evaluated are TAMS reliability and its relationship to intervals and man-hour calibration costs.

B. RELIABILITY

1. INTERVAL ADJUSTMENT PROCEDURES

The Metrology Data Systems office, MS35, of NWAD is responsible for acquiring, maintaining, and analyzing calibration data in order to determine reliability and establish TAMS calibration intervals. In this thesis, we will not address the initial establishment of intervals, but will instead focus on the procedures that pertain only to those items of TAMS that have established intervals and will be effected by the proposed changes.

The data used in interval adjustment comes from the Automated Calibration Interval Analysis System (ACIAS), which maintains a database on all items of TAMS. The database is built from the submissions of Metrology Equipment Recall (METER) cards from the calibration laboratories. METER cards contain data fields that are used to track numerous performance parameters down to a specific serial number. The data used in an analysis consists of resubmission data that satisfies certain conditions, and is

called a "Report of Calibration Interval Analysis" or "P2" data. The data processing that produces "P2" data is usually transparent to the analyst. Outliers, termed Dogs and Gems, are removed and the truncated data set is then considered representative of the model-manufacturer. Only in an atypical case, where calibration failure mode analysis is necessary, would the analyst look at the raw data. Although there is no written rule on the number of data sets required to conduct an analysis, the rule of thumb is that there be at least 30 resubmissions. However, most of the information needed is found in the number of Out-of-Tolerance (OOT) items. If the number of OOT's is moderate, a data set can be accepted even if the number of resubmissions is considerably less than 30 (Akiyama, 1995). Figure 5 is an example of a "P2"report.

```
Model: 1063   Cage: 94894
    n'' =     251         k = 0.0022
  oot'' =      10         T = 4497.5
                                         EOP
  Estimated Reliability:        0.95 0.90 0.85 0.80
  Calibration Interval (Mo):     23   48   74  101
  Confidence Limits for 0.85 Reliability:
    Two-Sided (90%):          43.1 - 134.8
    One-Sided (90% Upper):       117.4
    One-Sided (90% Lower):        47.5
```

Figure 5. Report of Calibration Interval Analysis " P2"

- n'' is the total number of items examined.
- oot'' is the number of Out-of-Tolerance items out of n''.
- k is the failure rate (also referred to as λ).
- T is the total operating time, in months, for items n''.
- Estimated Reliability and Calibration Intervals are derived using the exponential distribution equation (Figure 3) and the failure rate k.
- Confidence limits can be computed for any reliability by utilizing the chi squared distribution formula listed in Figure 6. The two-sided confidence limit utilizes α's of .05 for the lower and .95 for the upper along with ν's of 2(OOT+1) for the lower and 2(OOT) for the upper. The one-sided upper utilizes an α of .90 and a ν of 2(OOT). The one-sided lower utilizes an α of .10 and a ν of 2(OOT+1). As a statement of precision, the 90% confidence interval assures that in the long run, 90% of the confidence intervals obtained in this way will include the actual calibration "interval" (e.g., 24-months). Likewise, the 90% one-sided confidence limits state that in the long run, 90% of such confidence limits

will be equal to or greater than the actual "interval", in the case of calculating the lower such limit, and equal to or less than the actual "interval" in the case of calculating the upper limit (NAVAIR 17-35TR-5, 1986).

$$\frac{-4T\ \ln\ (R)}{\chi^2\ (\alpha;\nu)}$$

T - Total operating time

ln (R) - Log of reliability target in AOP

$\chi^2\ (\alpha;\nu)$ - Chi Squared statistic with α-quantile and ν-Degrees of freedom

Figure 6. Confidence Limit Formula (NAVAIR 17-35TR-5, 1986).

In deciding whether an adjustment needs to be done, the analyst will first look to see if the current interval falls within the 5% lower limit and the 95% upper limit of the two-sided confidence interval. If the actual interval falls below the low end of the range, the analyst will adjust the interval to the 10% lower confidence limit. If the actual interval falls above the high end of the range, the analyst would then adjust the interval to the 90% upper confidence

limit. The item in Figure 5 currently has an interval of 24 months, which lies below the lower range of 43.1 months. To correctly adjust this interval, the analyst would then default to the one-sided lower limit, making the new interval 47.5 or 48 months.

If the analysis shows that the interval change is "significant", meaning that the new interval minus the old interval, divided by the old interval is greater than one-third, the change must be reported as a "significant" change in the monthly Metrology Bulletin. In this thesis, the vast majority of items that fall in the 24 to 48 month interval would experience "significant" changes in their intervals.

In order to estimate how the population will react to the proposed changes, we will utilize sampling of at least 10 percent of the items that are contained in the 24 and 36 month intervals. From those samples, we will utilize "P2" data to predict the dispersion of items to their new intervals. Since the populations of the other intervals have no restrictions, it can be assumed that they are performing at their reliability target, thereby allowing us

to calculate their new intervals using only the exponential distribution equation.

C. BASELINE DATA

Baseline data, Figure 7, was obtained from NWAD. From the baseline data, the author has extracted all pertinent information from the study group, which consists of all items of TAMS with intervals that fall between 24 and 48 months.

INTR	MH/ YEAR	AIR INVENT	TOTAL MH	COST @ $40/HR	GPTE	SPTE
24	0.93	46,735	43,563.6	$ 1,742,542.00	**43,144**	**3,591**
25	1.87	722	1,350.2	$ 54,009.60	488	234
26	1.21	1,654	1,995.9	$ 79,835.08	1,611	43
27	1.02	1,347	1,375.2	$ 55,009.78	1,178	169
28	1.73	923	1,593.5	$ 63,738.86	695	228
29	1.32	709	939.1	$ 37,562.48	618	91
30	1.19	1,749	2,072.7	$ 82,907.20	1,604	145
31	1.08	549	593.3	$ 23,730.58	549	0
32	0.83	1,996	1,654.0	$ 66,159.00	1,912	84
33	1.16	568	661.1	$ 26,445.09	568	0
34	1.2	314	377.5	$ 15,098.82	276	38
35	0.63	16	10.1	$ 401.83	16	0
36	0.8	97,848	77,809.2	$ 3,112,368.00	**92,426**	**5,422**
37	2.22	53	117.6	$ 4,705.30	53	0
38	0.77	328	253.1	$ 10,125.47	328	0
40	0.41	236	96.8	$ 3,870.00	196	40
41	0.47	1	0.5	$ 18.73	1	0
42	0.65	388	250.5	$ 10,021.71	388	0
43	0.91	10	9.1	$ 363.91	10	0
48	0.68	5,525	3,763.1	$ 150,522.00	**5,525**	**0**

Figure 7. Interval Baseline data (Dwyer, 1997)
(Note: There are no items at the 39 and 44 - 47 interval)

- INTR: This is the interval in months.
- MH/YEAR: Man-hours expended per year per item of TAMS in that interval.
- AIR INVEN: Total number of items in the NAVAIR inventory at each interval.
- TOTAL MH: Total annual man-hours expended at each interval. Calculated by taking MH/YEAR times AIR INVEN.
- COST @ $40/HR: Standard labor charge used in cost analysis of calibration laboratories.
- GPTE: Number of items of General Purpose Test Equipment at that interval.
- SPTE: Number of items of Special Purpose Test Equipment at that interval.

D. INTERVAL CHANGE MODEL

We develop two interval change models that combines the baseline data, "P2" reports, and the confidence interval model in order to determine the effects of the changes to interval limits and reliability targets. The first model, Figure 8, calculates the interval change for those items that are currently performing at their reliability target.

This model is not applicable to the 24 and 36-month intervals, which contain numerous items that are performing well above their reliability targets.

a. Current Interval	τ
b. # Items GPTE @ 72%	A
c. # Items SPTE @ 85%	B
d. Failure rate for GPTE (λ)	ln .72 divided by τ
e. Failure rate for SPTE (λ)	ln .85 divided by τ
d. Calculated Interval GPTE @ 85%	ln .85 divided by $-\lambda$
e. Calculated Interval SPTE @ 90%	ln .90 divided by $-\lambda$
f. Recommended Action for GPTE	New interval or default to 24
g. Recommended Action for SPTE	New interval or default to 24

Figure 8. Interval Change Model for Items Performing at Reliability Target

- Rows a – c are self-explanatory and are found in the baseline data in Figure 7.
- Rows d – e are calculated using derivatives of the exponential distribution formula found in Figure 3.
- Rows f and g use a logic statement in their cells so that if the new interval is less than 24 months, it is to default to 24 months. If the new interval is greater than or equal to 24 months, it then takes the result from the "calculated interval" cell, e or f.

In order to determine the amount of items that are performing above their reliability targets in the 24 and 36 intervals, we will utilize the second model, Figure 9, which can take confidence intervals into account. These confidence intervals will determine the disbersion of items to their new intervals. By sampling as many items as possible, we will be able to accurately predict that dispersion.

a. Item Part Number/CAGE	X
b. SPTE or GPTE	X
c. Current Interval	τ
d. Number of Items in Inventory	Taken from SERMIS data
e. Percentage of Total Item in Interval	Cell d divided by total items in interval
f. Failure rate from P2 data (λ)	λ
g. Current Reliability	$e^{-\lambda\tau}$
h. Total Number of Items in P2 Report	n"
i. Number of Out-of-Tolerance out of n" from P2 Report	oot"
j. Confidence Limit Reliability Target in AOP (R)	.9218 AOP for GPTE or .9486 AOP for SPTE
k. Two Sided Confidence Limit Upper	$\frac{-4T \ln (R)}{\chi^2 (\alpha=.95;\nu=2(oot''))}$
l. Two Sided Confidence Limit Lower	$\frac{-4T \ln (R)}{\chi^2 (\alpha=.05;\nu=2(oot''+1))}$
m. One Sided Confidence Limit Upper	$\frac{-4T \ln (R)}{\chi^2 (\alpha=.90;\nu=2(oot''))}$
n. One Sided Confidence Limit Lower	$\frac{-4T \ln (R)}{\chi^2 (\alpha=.10;\nu=2(oot''+1))}$
o. Interval Change Decision	Dependant Upon Result From Confidence Interval Analysis

Figure 9. Interval Change Model for 24 and 36 Month Sample Items

- Rows a - d are the model's cells for the input data and are self-explanatory.
- Row d takes the number of items being analyzed and divides them by the total number of items at the 24 or 36

month interval, depending on which interval the item falls within. This data will be used later to estimate the dispersion of the entire population based on the results of each sample.

- Rows f - n are self-explanatory and were addressed in interval change procedures.
- Row o uses a logic statement so that if the current interval falls below the lower two-sided confidence limit, it will take the result of the lower one-sided confidence interval. If the current interval falls between the two-sided upper and lower limits, the item must stay at its current interval. If the current interval falls above the upper two-sided confidence limit, it will take the result of the upper one-sided confidence interval.

Once all samples are taken and run through the model, we will be able to calculate the dispersion of all items in that interval. For example, if we sample 10 percent of the total items at the 24 month interval, and we find that 50 percent move to 48 months, 25 percent move to 36 months and 25 percent stay at 24 months, we would then be able to

multiply those percentages by the total number of items at the 24 month interval. This will then give us an estimate of the dispersion of the entire population in that interval.

E. ANNUAL MAN-HOUR CALIBRATION COST MODEL

In order to compare the current costs to the projected costs, we have developed a cost model, Figure 10. By taking each interval's annual man-hour per item figures, from the baseline data, and multiplying them by the new number of items in each interval, we can estimate the total number of man-hours that will be expended at each interval. Then by taking the calibration laboratory standard labor rate of $40 per hour, we can calculate the estimated expenditures by interval. This will be compared to the current expenditures per interval, resulting in a comparative analysis of the two policies.

INTER	MH/ YEAR	OLD INVEN	NEW INVEN	NEW TOTAL MH	OLD COST	NEW COST	SAVINGS

Figure 10. Annual Calibration Man-hour Cost Model.

- INTER: Intervals from 24 to 48 months.
- MH/YEAR: Man-hours per year per item. Data taken from baseline data provided by NWAD.

- OLD INVEN: Old inventory by interval. Data taken from baseline data provided by NWAD.
- NEW INVEN: New inventory by interval. New inventories, by interval, are calculated by the interval change models.
- NEW TOTAL MH: Calculated by multiplying the man-hours per item per year times the new inventory.
- OLD COST: Old annual cost by interval. Data taken from baseline data provided by NWAD.
- NEW COST: Calculated by taking the new total man-hours per interval times $40 per hours standard labor charge.
- SAVINGS: Calculated by subtracting the new cost from the old cost.

IV. ANALYSIS

A. ITEMS PERFORMING AT THEIR RELIABILITY TARGETS

Utilizing the model in Figure 8, we analyzed the effect of raising the reliability targets from 72% to 85% EOP for GPTE and 85% to 90% EOP for SPTE. Each interval's output is contained in Appendix C. Figure 11 shows the compilation of all outputs.

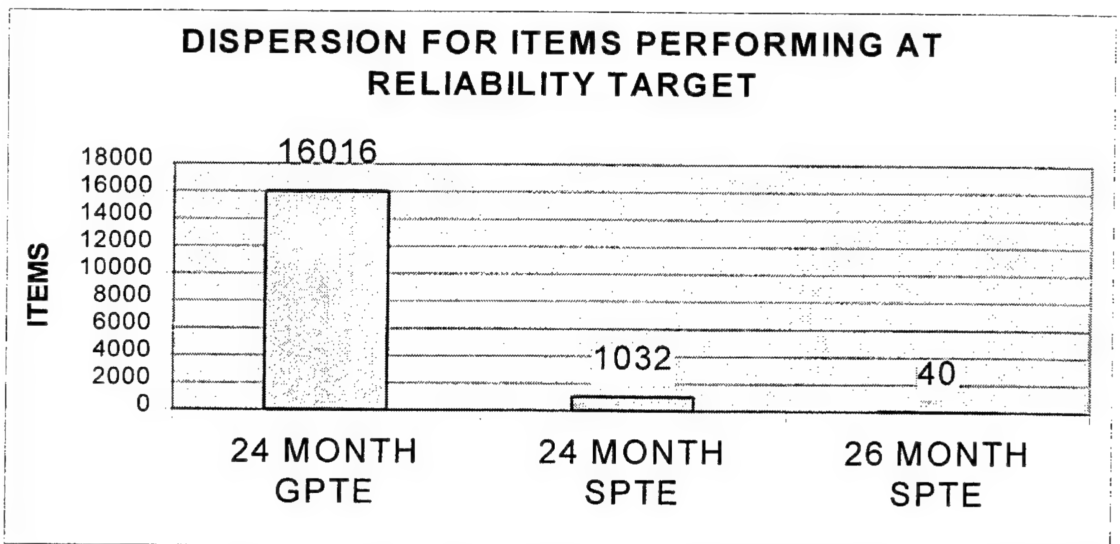

Figure 11. Results of Analysis of Items Performing at their Reliability Targets

Virtually every item, with the exception of the 40 items of SPTE at the 40 month interval, defaults back to the 24 month interval. This is a worst case scenario, but it ensures that cost savings are as conservative as possible.

In actual interval adjustment, all items would be examined separately, utilizing their respective "P2" reports. It is highly probable that many of the upper interval items would have strong enough confidence intervals that would result in a more optimistic outcome.

B. ITEMS PERFORMING ABOVE THEIR RELIABILITY TARGETS

We sampled a minimum of 14% and a maximum of 99% of the items contained within the 24 and 36 month populations. By extracting the applicable data from the "P2" reports and inputting it into the model, Figure 9, we analyzed the effect of raising the reliability targets from 72% to 85% EOP for GPTE and 85% to 90% EOP for SPTE. Each sample's output is contained in Appendix D.

1. 24 MONTH INTERVAL GPTE SAMPLE RESULTS

The 24 month GPTE population contains 43,144 items. 14.47% of those items were sampled, with the following breakout:

- 5.73% remain at the 24 month interval.
- .72% move to the 28 month interval.
- 2.41% move to the 45 month interval.
- 5.61% move to the new limit of 48 months.

By taking each of these percentages and dividing them by the total sample percentage (14.47%), then multiplying that percentage by the total items (43,144), we are able to estimate the dispersion of the population. Figure 12 graphically shows that dispersion.

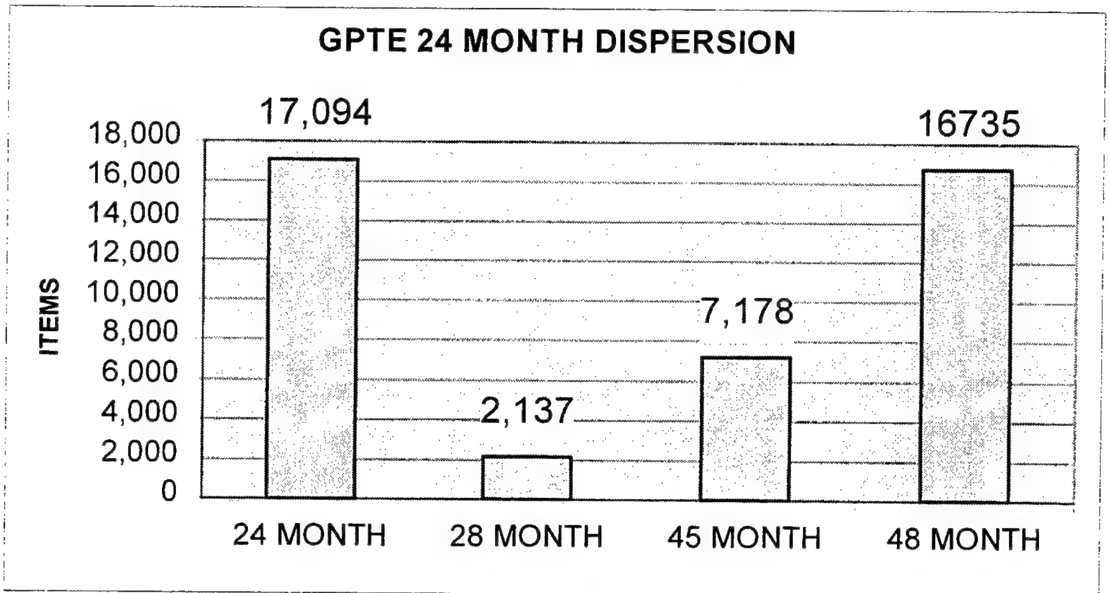

Figure 12. GPTE 24 Month Dispersion Analysis

2. 24 MONTH INTERVAL SPTE SAMPLE RESULTS

The 24 month SPTE population contains 3,591 items. Out of those 3,591 items, only 2,013 are at their maximum interval restriction. This removes 1,587 items from consideration of sampling. Of the 2,013 remaining items, 99.2% were sampled, with the following breakout:

- 16.19% remain at the 24 month interval.

* 58.72% move to the 31 month interval.
* 24.29% move to the 32 month interval.

By taking each of these percentages and dividing them by the total sample percentage (99.2%), then multiplying that percentage by the total items (2,013), we are able to estimate the dispersion of the population. Figure 13 graphically shows that dispersion.

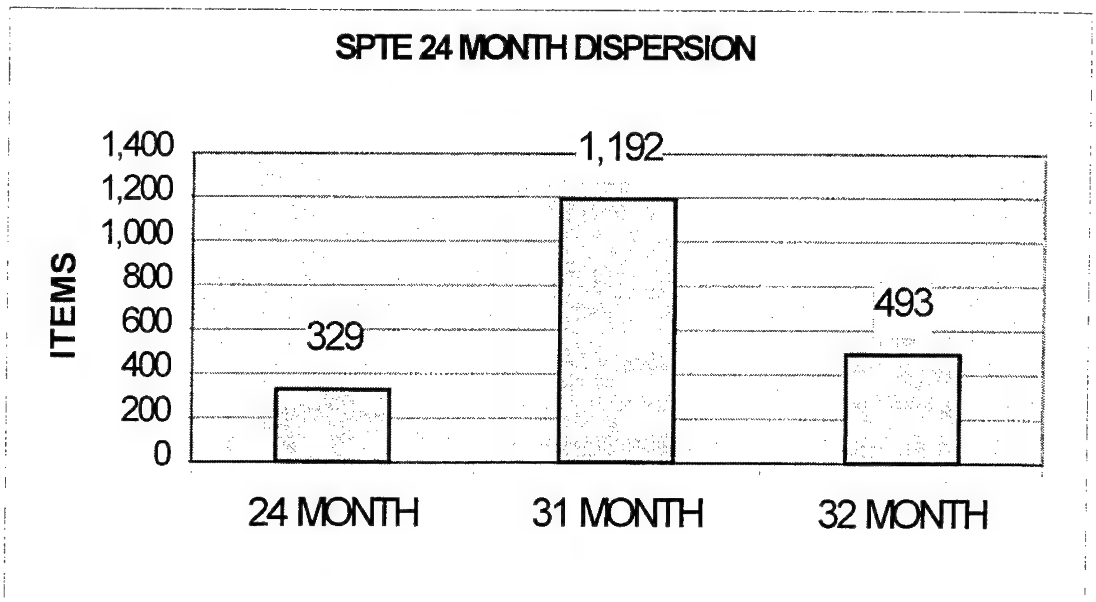

Figure 13. SPTE 24 Month Dispersion Analysis

3. 36 MONTH INTERVAL GPTE SAMPLE RESULTS

The 36 month GPTE population contains 92,426 items. 18.36% of those items were sampled with the following breakout:

- 4.73% remain at the 36 month interval.
- 13.63% move to the 48 month interval.

By taking each of these percentages and dividing them by the total sample percentage (18.36%), then multiplying that percentage by the total items (92,426), we are able to estimate the dispersion of the population. Figure 14 graphically shows that dispersion.

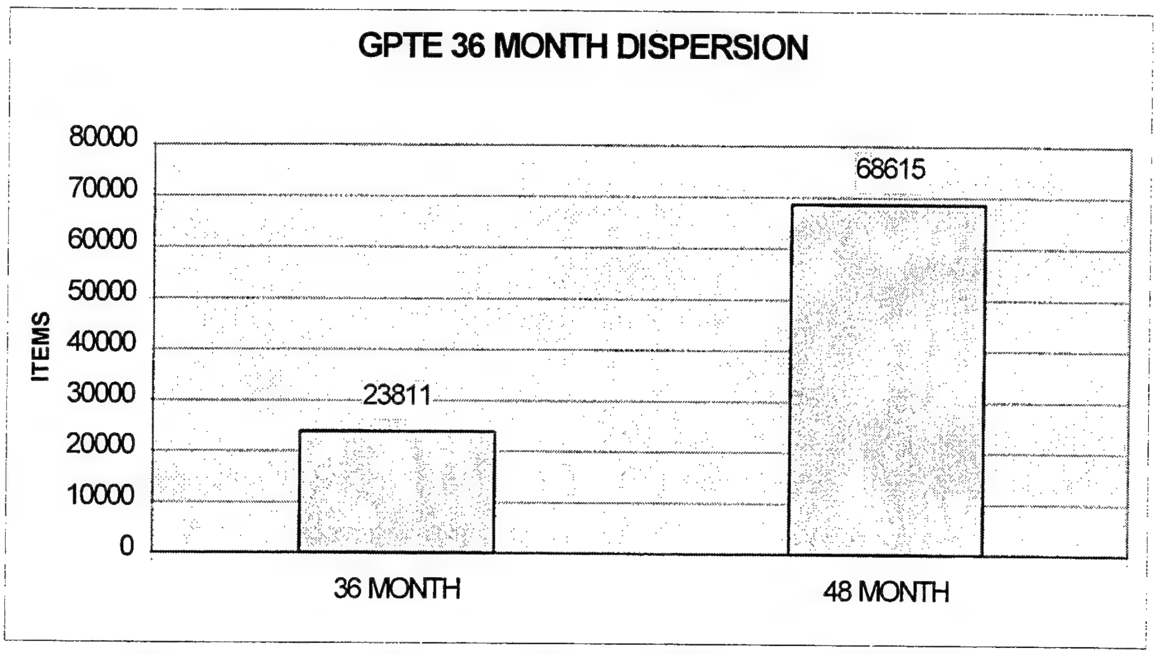

Figure 14. GPTE 36 Month Dispersion Analysis

4. 36 MONTH INTERVAL SPTE SAMPLE RESULTS

The 36 month SPTE population contains 5,422 items. 46.81% of those items were sampled with the following breakout:

- 4.74% are reduced back to the 24 month interval.
- 21.07% stay at the 36 month interval.
- 5.24% move to the 41 month interval.
- 4.52% move to the 43 month interval.
- 11.24% move to the 48 month interval.

By taking each of these percentages and dividing them by the total sample percentage (46.81%), then multiplying that percentage by the total items (5,422), we are able to estimate the dispersion of the population. Figure 15 graphically shows that dispersion.

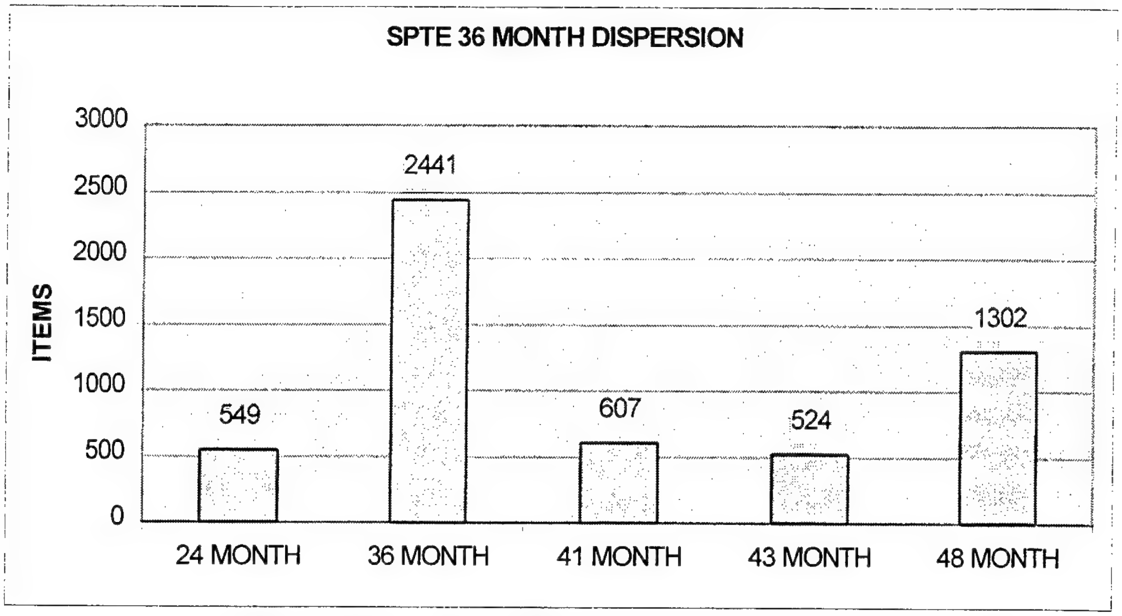

Figure 15. 36 Month Dispersion Analysis

5. MODEL CONSOLIDATION

Figure 16 shows the final result of the proposed policy change upon all of the items contained within the 24 to 48 month intervals. By utilizing a side-by-side comparison of old vs. new inventories, it clearly shows the large-scale migration of items to the right, thereby reducing the yearly man-hours expended on calibration.

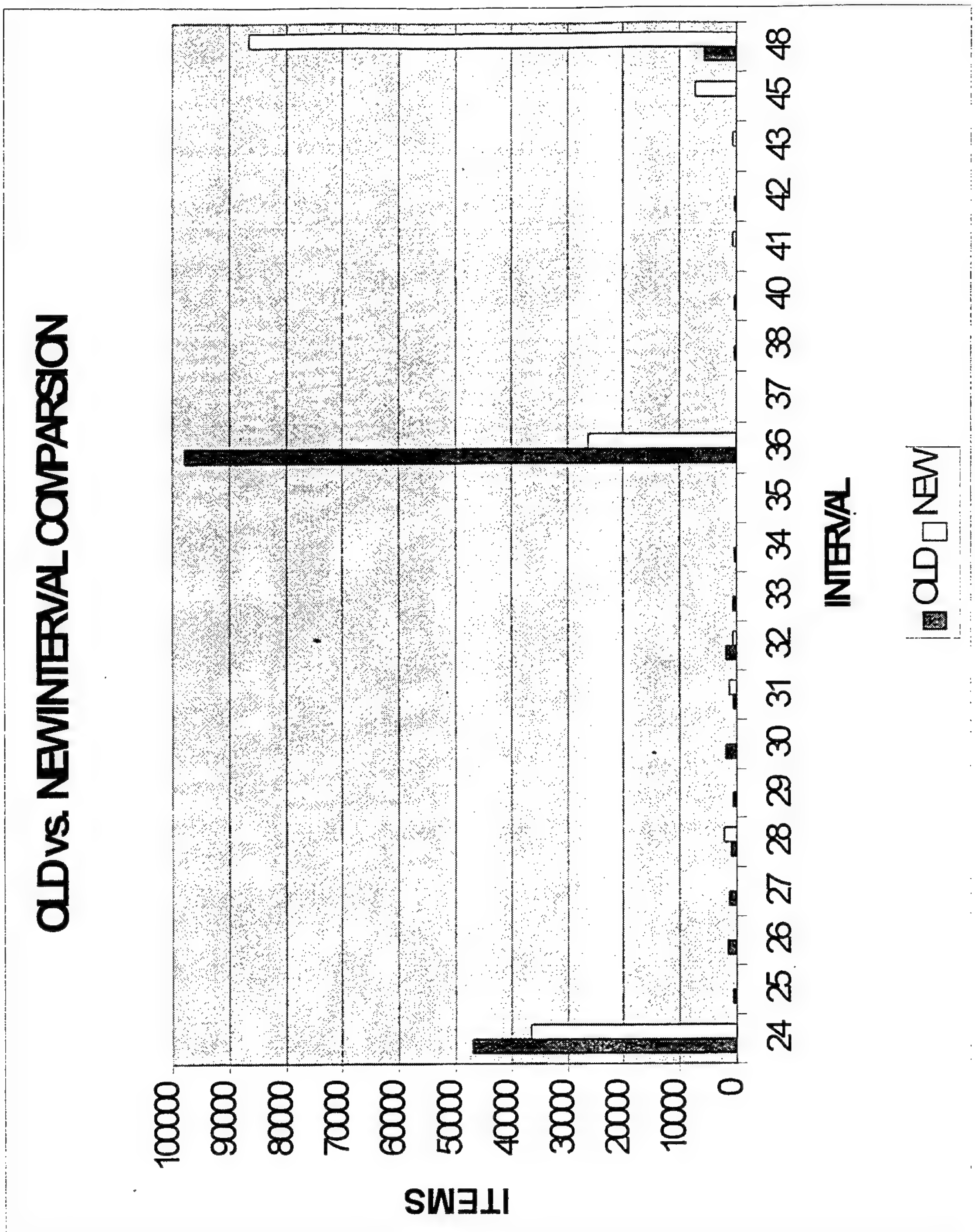

Figure 16. Old vs. New Interval Comparison

6. YEARLY SAVINGS

Figure 17 is a cost breakdown of the potential savings that could be gained by removing the maximum interval restrictions at the 24 and 36 month intervals. By removing the restrictions, the majority of the items shift to the longer intervals, which have a much lower man-hour per year cost. The total savings gained by removing these restrictions equals $1,284,509 a year.

INTVL	MH/YEAR	OLD INV	NEW INV	NEW MH	OLD COST	NEW COST	SAVINGS
24	0.93	46,735	36,596	34,034.28	1,742,542.00	1,361,371.20	381,170.80
25	1.87	722	0	0.00	54,009.60	-	54,009.60
26	1.21	1,654	40	48.40	79,835.08	1,936.00	77,899.08
27	1.02	1,347	0	0.00	55,009.78	-	55,009.78
28	1.73	923	2,137	3,697.01	63,738.86	147,880.40	(84,141.54)
29	1.32	709	0	0.00	37,562.48	-	37,562.48
30	1.19	1,749	0	0.00	82,907.20	-	82,907.20
31	1.08	549	1,192	1,287.36	23,730.58	51,494.40	(27,763.82)
32	0.83	1,996	493	409.19	66,159.00	16,367.60	49,791.40
33	1.16	568	0	0.00	26,445.09	-	26,445.09
34	1.2	314	0	0.00	15,098.82	-	15,098.82
35	0.63	16	0	0.00	401.83	-	401.83
36	0.8	97,848	26,252	21,001.60	3,112,368.00	840,064.00	2,272,304.00
37	2.22	53	0	0.00	4,705.30	-	4,705.30
38	0.77	328	0	0.00	10,125.47	-	10,125.47
40	0.41	236	0	0.00	3,870.00	-	3,870.00
41	0.47	1	607	285.29	18.73	11,411.60	(11,392.87)
42	0.65	388	0	0.00	10,021.71	-	10,021.71
43	0.91	10	524	476.84	363.91	19,073.60	(18,709.69)
45	0.795	0	7,178	5,706.51	-	228,260.40	(228,260.40)
48	0.455	5,525	86,652	39,426.66	150,522.00	1,577,066.40	(1,426,544.40)
					$ 5,539,435.44	$4,254,925.60	**$1,284,509.84**

Figure 17. Cost Analysis

C. RELIABILITY IMPROVEMENT

Figure 18 shows the computations involved in taking the current reliability of all items between 24 and 48 months and comparing them to the increased reliability requirements of the proposed policy modification.

TOTAL CURRENT GPTE	151586
CURRENT GPTE * .72	109141.9
TOTAL CURRENT SPTE	10085
CURRENT SPTE * .85	8572.25
CURRENT PROGRAM RELIABILITY	**72.81%**
24 MONTH GPTE	33110
24 MONTH GPTE * .72	23839.2
24 MONTH SPTE	1910
24 MONTH SPTE * .85	1623.5
TOTAL NEW GPTE 25 TO 48 MONTHS	118476
NEW GPTE * .85	100704.6
TOTAL NEW SPTE 25 TO 48 MONTHS	6599
NEW SPTE * .90	5939.1
NEW RELIABILITY	**82.52%**
RESULTING IMPROVEMENT IN RELIABILITY	**9.71%**

Figure 18. Program Reliability Computations

There is a 9.71% increase in the reliability of 46% of the items in the inventory. This increase in reliability should also have an impact on the number of A799's experienced in the fleet. However, there is no current system for directly measuring that benefit.

V. CONCLUSIONS

A. FINDINGS

This thesis provides an analysis of the modification of maximum calibration intervals and reliability goals. The following conclusions have been reached:

1. Change in Maximum Interval Restrictions Results in Calibration Man-hours Savings in Excess of $1.2 Million per Year

Test and Monitoring Systems are integral to the availability and safe operations of today's weapons system. Decreased budgets and scarce resources have further complicated this issue. By moving the 24 and 36 month maximum interval restrictions out to 48 months, along with increasing the reliability targets from 72% to 85% EOP for GPTE and 85% to 90% EOP for SPTE, as shown in Figure 16, could save the Navy calibration man-hour charges in excess of $1.2 million per year. As discussed in Chapter III, the models and the resulting cost savings are intended to outline the interrelationships and sensitivities of the key variables affected by reliability.

2. Increased TAMS Reliability Requirements Results in 9.71 Percent METCAL Program Reliability Improvement

Forty-six percent of all TAMS are contained within the 24 and 48 month intervals. Figure 17 shows the overall reliability improvement that can be gained by increasing the reliability targets for items with intervals greater than 24 months up to and including 48 months. This results in a reliability improvement of 9.71% for 46% of all items of TAMS in the NAVAIR inventory.

B. RECOMMENDATIONS

1. Change in Maximum Interval Restrictions Results in Calibration Man-hours Savings in Excess of $1.2 Million per Year

We recommend that the Navy extend the current 24 and 36 month calibration cycle limits to 48 months concurrently with the increased reliability targets of 85% EOP for GPTE and 90% EOP for SPTE. The potential savings from this change in policy are in excess of $1.2 million per year for the Navy.

2. Increased TAMS Reliability Requirements Results in 9.71 Percent METCAL Program Reliability Improvement

The increase in reliability requirements to 85% EOP for GPTE and 90% EOP for SPTE increases the reliability of 46% of Naval Aviation's TAMS by 9.71%. This improvement in reliability increases the ability of technicans to perform maintenance actions on todays weapons systems.

C. FINAL REMARKS

Downsizing and fiscal constraints are an inevitable reality faced by all DoD agencies. The impact of re-engineering current METCAL policies is only a small part of a much bigger picture. Nonetheless, through the use of analytical tools, it is the aggregate implementation of concepts like this, that can actually improve readiness while at the same time reduce the budget.

APPENDIX A

LIST OF ACRONYMS

ATE - Automated Test Equipment

ACIAS - Automated Calibration Interval Analysis System

AOP - Average-Over-the-Period

BIT - Built In Test

BITE - Built-In Test Equipment

EOP- End-of-Period

ETMC - Embedded Test and Monitoring Capabilities

GPTE - General Purpose Test Equipment

IFF- Interrogation Friend or Foe

JIT- Just-In-Time

MEASURE- Metrology Automated System for Uniform Recall and Reporting

METCAL- Metrology and Calibration

METER- Metrology Equipment Recall

NADEP- Naval Aviation Depot

NALDA- Naval Air Logistics Database

NAVAIR- Naval Air Systems Command

NAVAVNDEPOTOPSCEN- Naval Aviation Depot Operations Center

NWAD- Naval Warfare Assessment Division

OOT- Out-of-Tolerance

PME- Precision Measurement Equipment

SE- Support Equipment

SPTE- Special Purpose Test Equipment

SRA- Shop Replaceable Assembly

TAMS- Test and Monitoring Systems

TYCOMS- Type Commanders

WCF- Working Capitol Fund

WRA- Weapons System Repairable Assembly

APPENDIX B

MAXIMUM CALIBRATION INTERVALS

NOMENCLATURE	INTERVAL
ALTITUDE INDICATORS	24
AMPLIFIERS	24
ATTENUATORS SETS	24
ATTENUATORS, W/G FIXED	48
ATTENUATORS, W/G LEVEL SET	48
BRIDGES, DECADE SYNCHRONOUS ERROR	24
BRIDGES, KELVIN	48
BRIDGES, RATIO	48
DIVIDERS, INDUCTIVE	48
DIVIDERS, VOLTAGE	48
FILTERS, LOW PASS	60
FILTER SETS, LOW PASS	60
GAGES, PRESSURE	24
INDUCTORS, STANDARD	60
METERS, DC	40
METERS, FREQUENCY	48
METERS, FREQUENCY, COAX	42
MULTIPLIERS, VOLTAGE	48

TERMINATIONS, COAX	48
THERMISTOR MOUNTS, NON TEMP COMP	48
TORQUE TOOLS	24
TRANSFORMERS	48
WATTMETERS, RF	12

APPENDIX C

INTERVAL CHANGE MODEL RESULTS FOR ITEMS PERFORMING AT

THEIR RELIABILITY TARGETS

a. Current Interval	25
b. # Items GPTE @ 72%	488
c. # Items SPTE @ 85%	234
d. Failure Rate for GPTE (lambda)	-0.0131
e. Failure Rate for SPTE (lambda)	-0.0065
f. Calculated Interval GPTE @ 85%	12.3681
g. Calculated Interval SPTE @ 90%	16.2074
h. Recommended Action for GPTE	**Default to 24**
i. Recommended Action for SPTE	**Default to 24**

a. Current Interval	26
b. # Items GPTE @ 72%	1611
c. # Items SPTE @ 85%	43
d. Failure Rate for GPTE (lambda)	-0.0126
e. Failure Rate for SPTE (lambda)	-0.0063
f. Calculated Interval GPTE @ 85%	12.8628
g. Calculated Interval SPTE @ 90%	16.8557
h. Recommended Action for GPTE	**Default to 24**
i. Recommended Action for SPTE	**Default to 24**

a. Current Interval	27
b. # Items GPTE @ 72%	1178
c. # Items SPTE @ 85%	169
d. Failure Rate for GPTE (lambda)	-0.0122
e. Failure Rate for SPTE (lambda)	-0.0060
f. Calculated Interval GPTE @ 85%	13.3576
g. Calculated Interval SPTE @ 90%	17.5040
h. Recommended Action for GPTE	**Default to 24**
i. Recommended Action for SPTE	**Default to 24**

a. Current Interval	28
b. # Items GPTE @ 72%	695
c. # Items SPTE @ 85%	228
d. Failure Rate for GPTE (lambda)	**-0.0117**
e. Failure Rate for SPTE (lambda)	**-0.0058**
f. Calculated Interval GPTE @ 85%	**13.8523**
g. Calculated Interval SPTE @ 90%	**18.1523**
h. Recommended Action for GPTE	**Default to 24**
i. Recommended Action for SPTE	**Default to 24**

a. Current Interval	29
b. # Items GPTE @ 72%	618
c. # Items SPTE @ 85%	91
d. Failure Rate for GPTE (lambda)	**-0.0113**
e. Failure Rate for SPTE (lambda)	**-0.0056**
f. Calculated Interval GPTE @ 85%	**14.3470**
g. Calculated Interval SPTE @ 90%	**18.8006**
h. Recommended Action for GPTE	**Default to 24**
i. Recommended Action for SPTE	**Default to 24**

a. Current Interval	30
b. # Items GPTE @ 72%	1604
c. # Items SPTE @ 85%	145
d. Failure Rate for GPTE (lambda)	**-0.0110**
e. Failure Rate for SPTE (lambda)	**-0.0054**
f. Calculated Interval GPTE @ 85%	**14.8417**
g. Calculated Interval SPTE @ 90%	**19.4489**
h. Recommended Action for GPTE	**Default to 24**
i. Recommended Action for SPTE	**Default to 24**

a. Current Interval	31
b. # Items GPTE @ 72%	549
c. # Items SPTE @ 85%	0
d. Failure Rate for GPTE (lambda)	-0.0106
e. Failure Rate for SPTE (lambda)	-0.0052
f. Calculated Interval GPTE @ 85%	15.3365
g. Calculated Interval SPTE @ 90%	20.0972
h. Recommended Action for GPTE	**Default to 24**
i. Recommended Action for SPTE	**Default to 24**

a. Current Interval	32
b. # Items GPTE @ 72%	1912
c. # Items SPTE @ 85%	84
d. Failure Rate for GPTE (lambda)	-0.0103
e. Failure Rate for SPTE (lambda)	-0.0051
f. Calculated Interval GPTE @ 85%	15.8312
g. Calculated Interval SPTE @ 90%	20.7455
h. Recommended Action for GPTE	**Default to 24**
i. Recommended Action for SPTE	**Default to 24**

a. Current Interval	33
b. # Items GPTE @ 72%	568
c. # Items SPTE @ 85%	0
d. Failure Rate for GPTE (lambda)	-0.0100
e. Failure Rate for SPTE (lambda)	-0.0049
f. Calculated Interval GPTE @ 85%	16.3259
g. Calculated Interval SPTE @ 90%	21.3938
h. Recommended Action for GPTE	**Default to 24**
i. Recommended Action for SPTE	**Default to 24**

a. Current Interval	34
b. # Items GPTE @ 72%	276
c. # Items SPTE @ 85%	38
d. Failure Rate for GPTE (lambda)	-0.0097
e. Failure Rate for SPTE (lambda)	-0.0048
f. Calculated Interval GPTE @ 85%	16.8206
g. Calculated Interval SPTE @ 90%	22.0421
h. Recommended Action for GPTE	Default to 24
i. Recommended Action for SPTE	Default to 24

a. Current Interval	35
b. # Items GPTE @ 72%	16
c. # Items SPTE @ 85%	0
d. Failure Rate for GPTE (lambda)	-0.0094
e. Failure Rate for SPTE (lambda)	-0.0046
f. Calculated Interval GPTE @ 85%	17.3153
g. Calculated Interval SPTE @ 90%	22.6904
h. Recommended Action for GPTE	Default to 24
i. Recommended Action for SPTE	Default to 24

a. Current Interval	37
b. # Items GPTE @ 72%	53
c. # Items SPTE @ 85%	0
d. Failure Rate for GPTE (lambda)	-0.0089
e. Failure Rate for SPTE (lambda)	-0.0044
f. Calculated Interval GPTE @ 85%	18.3048
g. Calculated Interval SPTE @ 90%	23.9870
h. Recommended Action for GPTE	Default to 24
i. Recommended Action for SPTE	Default to 24

a. Current Interval	38
b. # Items GPTE @ 72%	328
c. # Items SPTE @ 85%	0
d. Failure Rate for GPTE (lambda)	-0.0086
e. Failure Rate for SPTE (lambda)	-0.0043
f. Calculated Interval GPTE @ 85%	18.7995
g. Calculated Interval SPTE @ 90%	24.6353
h. Recommended Action for GPTE	Default to 24
i. Recommended Action for SPTE	24.63528161

a. Current Interval	40
b. # Items GPTE @ 72%	196
c. # Items SPTE @ 85%	40
d. Failure Rate for GPTE (lambda)	-0.0082
e. Failure Rate for SPTE (lambda)	-0.0041
f. Calculated Interval GPTE @ 85%	19.7890
g. Calculated Interval SPTE @ 90%	25.9319
h. Recommended Action for GPTE	Default to 24
i. Recommended Action for SPTE	25.93187538

a. Current Interval	41
b. # Items GPTE @ 72%	1
c. # Items SPTE @ 85%	0
d. Failure Rate for GPTE (lambda)	-0.0080
e. Failure Rate for SPTE (lambda)	-0.0040
f. Calculated Interval GPTE @ 85%	20.2837
g. Calculated Interval SPTE @ 90%	26.5802
h. Recommended Action for GPTE	Default to 24
i. Recommended Action for SPTE	26.58017226

a. Current Interval	42
b. # Items GPTE @ 72%	388
c. # Items SPTE @ 85%	0
d. Failure Rate for GPTE (lambda)	-0.0078
e. Failure Rate for SPTE (lambda)	-0.0039
f. Calculated Interval GPTE @ 85%	20.7784
g. Calculated Interval SPTE @ 90%	27.2285
h. Recommended Action for GPTE	Default to 24
i. Recommended Action for SPTE	27.22846915

a. Current Interval	43
b. # Items GPTE @ 72%	10
c. # Items SPTE @ 85%	0
d. Failure Rate for GPTE (lambda)	-0.0076
e. Failure Rate for SPTE (lambda)	-0.0038
f. Calculated Interval GPTE @ 85%	21.2731
g. Calculated Interval SPTE @ 90%	27.8768
h. Recommended Action for GPTE	Default to 24
i. Recommended Action for SPTE	27.87676603

a. Current Interval	48
b. # Items GPTE @ 72%	5525
c. # Items SPTE @ 85%	0
d. Failure Rate for GPTE (lambda)	-0.0068
e. Failure Rate for SPTE (lambda)	-0.0034
f. Calculated Interval GPTE @ 85%	23.7468
g. Calculated Interval SPTE @ 90%	31.1183
h. Recommended Action for GPTE	Default to 24
i. Recommended Action for SPTE	31.11825045

APPENDIX D

INTERVAL CHANGE RESULTS FROM SAMPLED ITEMS PERFORMING ABOVE THEIR RELIABILITY TARGETS

a. Item Part Number/CAGE	7502MR/08194
b. SPTE or GPTE	GPTE
c. Current Interval	24
d. Number of Items in Inventory	1038
e. Percentage of Total Item in Interval	2.41%
d. Failure rate from P2 data (-lambda)	-0.0027
e. Current Reliability	93.73%
f. Total Number of Items in P2 Report	417
g. Number OOT from P2	23
h. Total Time from P2 Report	8413.5
h. Confidence Limit Reliability Target in AOP (R)	92.18%
i. Two Sided Confidence Limit Upper	87.16
j. Two Sided Confidence Limit Lower	42.05
k. One Sided Confidence Limit Upper	80.09
h. One Sided Confidence Limit Lower	44.99
e. Recommended Action	45

a. Item Part Number/CAGE	0-200PSI/64467
b. SPTE or GPTE	GPTE
c. Current Interval	24
d. Number of Items in Inventory	947
e. Percentage of Total Item in Interval	2.20%
d. Failure rate from P2 data (-lambda)	-0.0006
e. Current Reliability	98.57%
f. Total Number of Items in P2 Report	699
g. Number OOT from P2	10
h. Total Time from P2 Report	15,524.5
h. Confidence Limit Reliability Target in AOP (R)	0.9218
i. Two Sided Confidence Limit Upper	466.00
j. Two Sided Confidence Limit Lower	149.05
k. One Sided Confidence Limit Upper	406.38
h. One Sided Confidence Limit Lower	164.10
e. Recommended Action	48

a. Item Part Number/CAGE	0-4000PSI/61349
b. SPTE or GPTE	GPTE
c. Current Interval	24
d. Number of Items in Inventory	887
e. Percentage of Total Item in Interval	2.06%
d. Failure rate from P2 data (-lambda)	-0.0058
e. Current Reliability	87.01%
f. Total Number of Items in P2 Report	1740
g. Number OOT from P2	72
h. Total Time from P2 Report	12,348.0
h. Confidence Limit Reliability Target in AOP (R)	0.9218
i. Two Sided Confidence Limit Upper	34.30
j. Two Sided Confidence Limit Lower	22.96
k. One Sided Confidence Limit Upper	32.77
h. One Sided Confidence Limit Lower	23.90
e. Recommended Action	24

a. Item Part Number/CAGE	0-200PSI/61349
b. SPTE or GPTE	GPTE
c. Current Interval	24
d. Number of Items in Inventory	857
e. Percentage of Total Item in Interval	1.99%
d. Failure rate from P2 data (-lambda)	-0.0049
e. Current Reliability	88.91%
f. Total Number of Items in P2 Report	428
g. Number OOT from P2	17
h. Total Time from P2 Report	3,440.5
h. Confidence Limit Reliability Target in AOP (R)	0.9218
i. Two Sided Confidence Limit Upper	51.73
j. Two Sided Confidence Limit Lower	21.97
k. One Sided Confidence Limit Upper	47.78
h. One Sided Confidence Limit Lower	23.74
e. Recommended Action	24

a. Item Part Number/CAGE	7502M/08194
b. SPTE or GPTE	GPTE
c. Current Interval	24
d. Number of Items in Inventory	728
e. Percentage of Total Item in Interval	1.69%
d. Failure rate from P2 data (-lambda)	-0.0039
e. Current Reliability	91.06%
f. Total Number of Items in P2 Report	108
g. Number OOT from P2	8
h. Total Time from P2 Report	2,055.0
h. Confidence Limit Reliability Target in AOP (R)	0.9218
i. Two Sided Confidence Limit Upper	84.07
j. Two Sided Confidence Limit Lower	23.18
k. One Sided Confidence Limit Upper	71.88
h. One Sided Confidence Limit Lower	25.75
e. Recommended Action	24

a. Item Part Number/CAGE	0-100PSI/64467
b. SPTE or GPTE	GPTE
c. Current Interval	24
d. Number of Items in Inventory	384
e. Percentage of Total Item in Interval	0.89%
d. Failure rate from P2 data (-lambda)	-0.0007
e. Current Reliability	98.33%
f. Total Number of Items in P2 Report	695
g. Number OOT from P2	11
h. Total Time from P2 Report	14,793.0
h. Confidence Limit Reliability Target in AOP (R)	0.9218
i. Two Sided Confidence Limit Upper	390.52
j. Two Sided Confidence Limit Lower	132.31
k. One Sided Confidence Limit Upper	343.14
h. One Sided Confidence Limit Lower	145.14
e. Recommended Action	48

a. Item Part Number/CAGE	0-160PSI/61349
b. SPTE or GPTE	GPTE
c. Current Interval	24
d. Number of Items in Inventory	463
e. Percentage of Total Item in Interval	1.07%
d. Failure rate from P2 data (-lambda)	-0.0011
e. Current Reliability	97.39%
f. Total Number of Items in P2 Report	239
g. Number OOT from P2	2
h. Total Time from P2 Report	1,774.5
h. Confidence Limit Reliability Target in AOP (R)	0.9218
i. Two Sided Confidence Limit Upper	813.21
j. Two Sided Confidence Limit Lower	45.90
k. One Sided Confidence Limit Upper	543.40
h. One Sided Confidence Limit Lower	54.30
e. Recommended Action	48

a. Item Part Number/CAGE	8100/87641
b. SPTE or GPTE	GPTE
c. Current Interval	24
d. Number of Items in Inventory	353
e. Percentage of Total Item in Interval	0.82%
d. Failure rate from P2 data (-lambda)	-0.0001
e. Current Reliability	99.76%
f. Total Number of Items in P2 Report	403
g. Number OOT from P2	1
h. Total Time from P2 Report	10,727.5
h. Confidence Limit Reliability Target in AOP (R)	0.9218
i. Two Sided Confidence Limit Upper	34,059.46
j. Two Sided Confidence Limit Lower	368.27
k. One Sided Confidence Limit Upper	16,581.34
h. One Sided Confidence Limit Lower	449.14
e. Recommended Action	48

a. Item Part Number/CAGE	G61105/62016
b. SPTE or GPTE	GPTE
c. Current Interval	24
d. Number of Items in Inventory	309
e. Percentage of Total Item in Interval	0.72%
d. Failure rate from P2 data (-lambda)	-0.0036
e. Current Reliability	91.72%
f. Total Number of Items in P2 Report	101
g. Number OOT from P2	8
h. Total Time from P2 Report	2,223.0
h. Confidence Limit Reliability Target in AOP (R)	0.9218
i. Two Sided Confidence Limit Upper	90.94
j. Two Sided Confidence Limit Lower	25.08
k. One Sided Confidence Limit Upper	77.75
h. One Sided Confidence Limit Lower	27.86
e. Recommended Action	28

a. Item Part Number/CAGE	0-15PSI/61349
b. SPTE or GPTE	GPTE
c. Current Interval	24
d. Number of Items in Inventory	273
e. Percentage of Total Item in Interval	0.63%
d. Failure rate from P2 data (-lambda)	-0.0007
e. Current Reliability	98.33%
f. Total Number of Items in P2 Report	327
g. Number OOT from P2	2
h. Total Time from P2 Report	2,862.5
h. Confidence Limit Reliability Target in AOP (R)	0.9218
i. Two Sided Confidence Limit Upper	1,311.82
j. Two Sided Confidence Limit Lower	74.04
k. One Sided Confidence Limit Upper	876.57
h. One Sided Confidence Limit Lower	87.59
e. Recommended Action	48

a. Item Part Number/CAGE	1063/94894
b. SPTE or GPTE	SPTE
c. Current Interval	24
d. Number of Items in Inventory	1182
e. Percentage of Total Item in Interval	58.72%
d. Failure rate from P2 data (-lambda)	-0.0022
e. Current Reliability	94.86%
f. Total Number of Items in P2 Report	251
g. Number OOT from P2	10
h. Total Time from P2 Report	4,497.5
h. Confidence Limit Reliability Target in AOP (R)	0.9486
i. Two Sided Confidence Limit Upper	87.49
j. Two Sided Confidence Limit Lower	27.98
k. One Sided Confidence Limit Upper	76.29
h. One Sided Confidence Limit Lower	30.81
e. Recommended Action	31

a. Item Part Number/CAGE	1066/94894
b. SPTE or GPTE	SPTE
c. Current Interval	24
d. Number of Items in Inventory	489
e. Percentage of Total Item in Interval	24.29%
d. Failure rate from P2 data (-lambda)	-0.0021
e. Current Reliability	95.08%
f. Total Number of Items in P2 Report	216
g. Number OOT from P2	9
h. Total Time from P2 Report	4,326.0
h. Confidence Limit Reliability Target in AOP (R)	0.9486
i. Two Sided Confidence Limit Upper	97.24
j. Two Sided Confidence Limit Lower	29.07
k. One Sided Confidence Limit Upper	84.04
h. One Sided Confidence Limit Lower	32.14
e. Recommended Action	32

a. Item Part Number/CAGE	1067/94894
b. SPTE or GPTE	SPTE
c. Current Interval	24
d. Number of Items in Inventory	208
e. Percentage of Total Item in Interval	10.33%
d. Failure rate from P2 data (-lambda)	-0.0159
e. Current Reliability	68.28%
f. Total Number of Items in P2 Report	10204
g. Number OOT from P2	332
h. Total Time from P2 Report	20,904.0
h. Confidence Limit Reliability Target in AOP (R)	0.9486
i. Two Sided Confidence Limit Upper	7.29
j. Two Sided Confidence Limit Lower	6.07
k. One Sided Confidence Limit Upper	7.14
h. One Sided Confidence Limit Lower	6.19
e. Recommended Action	24

a. Item Part Number/CAGE	631AS100-1/14727
b. SPTE or GPTE	SPTE
c. Current Interval	24
d. Number of Items in Inventory	118
e. Percentage of Total Item in Interval	5.86%
d. Failure rate from P2 data (-lambda)	-0.0081
e. Current Reliability	82.33%
f. Total Number of Items in P2 Report	2353
g. Number OOT from P2	64
h. Total Time from P2 Report	7,936.0
h. Confidence Limit Reliability Target in AOP (R)	0.9486
i. Two Sided Confidence Limit Upper	16.28
j. Two Sided Confidence Limit Lower	10.63
k. One Sided Confidence Limit Upper	15.51
h. One Sided Confidence Limit Lower	11.09
e. Recommended Action	24

a. Item Part Number/CAGE	8481A/28480
b. SPTE or GPTE	GPTE
c. Current Interval	36
d. Number of Items in Inventory	1533
e. Percentage of Total Item in Interval	1.66%
d. Failure rate from P2 data (-lambda)	-0.0002
e. Current Reliability	99.28%
f. Total Number of Items in P2 Report	901
g. Number OOT from P2	6
h. Total Time from P2 Report	33,322.0
h. Confidence Limit Reliability Target in AOP (R)	0.9218
i. Two Sided Confidence Limit Upper	2,076.77
j. Two Sided Confidence Limit Lower	458.24
k. One Sided Confidence Limit Upper	1,721.70
h. One Sided Confidence Limit Lower	515.25
e. Recommended Action	48

a. Item Part Number/CAGE	7B53A/80009
b. SPTE or GPTE	GPTE
c. Current Interval	36
d. Number of Items in Inventory	1101
e. Percentage of Total Item in Interval	1.19%
d. Failure rate from P2 data (-lambda)	-0.0045
e. Current Reliability	85.04%
f. Total Number of Items in P2 Report	138
g. Number OOT from P2	19
h. Total Time from P2 Report	4,203.5
h. Confidence Limit Reliability Target in AOP (R)	0.9218
i. Two Sided Confidence Limit Upper	55.02
j. Two Sided Confidence Limit Lower	24.55
k. One Sided Confidence Limit Upper	50.07
h. One Sided Confidence Limit Lower	26.43
e. Recommended Action	36

a. Item Part Number/CAGE	848A/28480
b. SPTE or GPTE	GPTE
c. Current Interval	36
d. Number of Items in Inventory	1021
e. Percentage of Total Item in Interval	1.10%
d. Failure rate from P2 data (-lambda)	-0.0007
e. Current Reliability	97.51%
f. Total Number of Items in P2 Report	159
g. Number OOT from P2	4
h. Total Time from P2 Report	5,986.5
h. Confidence Limit Reliability Target in AOP (R)	0.9218
i. Two Sided Confidence Limit Upper	713.54
j. Two Sided Confidence Limit Lower	106.51
k. One Sided Confidence Limit Upper	558.77
h. One Sided Confidence Limit Lower	121.96
e. Recommended Action	48

a. Item Part Number/CAGE	85RF/89536
b. SPTE or GPTE	GPTE
c. Current Interval	36
d. Number of Items in Inventory	994
e. Percentage of Total Item in Interval	1.08%
d. Failure rate from P2 data (-lambda)	-0.001
e. Current Reliability	96.46%
f. Total Number of Items in P2 Report	1726
g. Number OOT from P2	49
h. Total Time from P2 Report	49,367.5
h. Confidence Limit Reliability Target in AOP (R)	0.9218
i. Two Sided Confidence Limit Upper	211.12
j. Two Sided Confidence Limit Lower	129.32
k. One Sided Confidence Limit Upper	199.64
h. One Sided Confidence Limit Lower	135.69
e. Recommended Action	48

a. Item Part Number/CAGE	80K6/89536
b. SPTE or GPTE	GPTE
c. Current Interval	36
d. Number of Items in Inventory	840
e. Percentage of Total Item in Interval	0.91%
d. Failure rate from P2 data (-lambda)	-0.0001
e. Current Reliability	99.64%
f. Total Number of Items in P2 Report	836
g. Number OOT from P2	1
h. Total Time from P2 Report	49,367.5
h. Confidence Limit Reliability Target in AOP (R)	0.9218
i. Two Sided Confidence Limit Upper	156,740.21
j. Two Sided Confidence Limit Lower	1,694.76
k. One Sided Confidence Limit Upper	76,306.61
h. One Sided Confidence Limit Lower	2,066.91
e. Recommended Action	48

a. Item Part Number/CAGE	11708A/28480
b. SPTE or GPTE	GPTE
c. Current Interval	36
d. Number of Items in Inventory	832
e. Percentage of Total Item in Interval	0.90%
d. Failure rate from P2 data (-lambda)	-0.0001
e. Current Reliability	99.64%
f. Total Number of Items in P2 Report	340
g. Number OOT from P2	1
h. Total Time from P2 Report	12,640.0
h. Confidence Limit Reliability Target in AOP (R)	0.9218
i. Two Sided Confidence Limit Upper	40,131.59
j. Two Sided Confidence Limit Lower	433.92
k. One Sided Confidence Limit Upper	19,537.46
h. One Sided Confidence Limit Lower	529.21
e. Recommended Action	48

a. Item Part Number/CAGE	120/57163
b. SPTE or GPTE	GPTE
c. Current Interval	36
d. Number of Items in Inventory	803
e. Percentage of Total Item in Interval	0.87%
d. Failure rate from P2 data (-lambda)	-0.0016
e. Current Reliability	94.40%
f. Total Number of Items in P2 Report	332
g. Number OOT from P2	9
h. Total Time from P2 Report	5,539.0
h. Confidence Limit Reliability Target in AOP (R)	0.9218
i. Two Sided Confidence Limit Upper	192.12
j. Two Sided Confidence Limit Lower	57.44
k. One Sided Confidence Limit Upper	166.05
h. One Sided Confidence Limit Lower	63.50
e. Recommended Action	48

a. Item Part Number/CAGE	478A/28480
b. SPTE or GPTE	GPTE
c. Current Interval	36
d. Number of Items in Inventory	797
e. Percentage of Total Item in Interval	0.86%
d. Failure rate from P2 data (-lambda)	-0.0018
e. Current Reliability	93.73%
f. Total Number of Items in P2 Report	8758
g. Number OOT from P2	446
h. Total Time from P2 Report	251,778.0
h. Confidence Limit Reliability Target in AOP (R)	0.9218
i. Two Sided Confidence Limit Upper	99.56
j. Two Sided Confidence Limit Lower	85.01
k. One Sided Confidence Limit Upper	97.82
h. One Sided Confidence Limit Lower	86.45
e. Recommended Action	48

a. Item Part Number/CAGE	851LRV/60998
b. SPTE or GPTE	GPTE
c. Current Interval	36
d. Number of Items in Inventory	768
e. Percentage of Total Item in Interval	0.83%
d. Failure rate from P2 data (-lambda)	-0.0004
e. Current Reliability	98.57%
f. Total Number of Items in P2 Report	135
g. Number OOT from P2	2
h. Total Time from P2 Report	4,875.0
h. Confidence Limit Reliability Target in AOP (R)	0.9218
i. Two Sided Confidence Limit Upper	2,234.10
j. Two Sided Confidence Limit Lower	126.10
k. One Sided Confidence Limit Upper	1,492.85
h. One Sided Confidence Limit Lower	149.17
e. Recommended Action	48

a. Item Part Number/CAGE	8478E/28480
b. SPTE or GPTE	GPTE
c. Current Interval	36
d. Number of Items in Inventory	691
e. Percentage of Total Item in Interval	0.75%
d. Failure rate from P2 data (-lambda)	-0.0009
e. Current Reliability	96.81%
f. Total Number of Items in P2 Report	4170
g. Number OOT from P2	108
h. Total Time from P2 Report	116,226.5
h. Confidence Limit Reliability Target in AOP (R)	0.9218
i. Two Sided Confidence Limit Upper	206.88
j. Two Sided Confidence Limit Lower	149.37
k. One Sided Confidence Limit Upper	199.42
h. One Sided Confidence Limit Lower	154.42
e. Recommended Action	48

a. Item Part Number/CAGE	432A/28480
b. SPTE or GPTE	GPTE
c. Current Interval	36
d. Number of Items in Inventory	684
e. Percentage of Total Item in Interval	0.74%
d. Failure rate from P2 data (-lambda)	-0.0012
e. Current Reliability	95.77%
f. Total Number of Items in P2 Report	67
g. Number OOT from P2	3
h. Total Time from P2 Report	2,445.5
h. Confidence Limit Reliability Target in AOP (R)	0.9218
i. Two Sided Confidence Limit Upper	487.05
j. Two Sided Confidence Limit Lower	51.36
k. One Sided Confidence Limit Upper	361.38
h. One Sided Confidence Limit Lower	59.61
e. Recommended Action	48

a. Item Part Number/CAGE	8640E/28480
b. SPTE or GPTE	GPTE
c. Current Interval	36
d. Number of Items in Inventory	681
e. Percentage of Total Item in Interval	0.74%
d. Failure rate from P2 data (-lambda)	-0.0035
e. Current Reliability	88.16%
f. Total Number of Items in P2 Report	57
g. Number OOT from P2	7
h. Total Time from P2 Report	2,445.5
h. Confidence Limit Reliability Target in AOP (R)	0.9218
i. Two Sided Confidence Limit Upper	121.22
j. Two Sided Confidence Limit Lower	30.29
k. One Sided Confidence Limit Upper	102.25
h. One Sided Confidence Limit Lower	33.83
e. Recommended Action	36

a. Item Part Number/CAGE	T5-8002/45042
b. SPTE or GPTE	GPTE
c. Current Interval	36
d. Number of Items in Inventory	676
e. Percentage of Total Item in Interval	0.73%
d. Failure rate from P2 data (-lambda)	-0.0094
e. Current Reliability	71.29%
f. Total Number of Items in P2 Report	71
g. Number OOT from P2	1
h. Total Time from P2 Report	106.0
h. Confidence Limit Reliability Target in AOP (R)	0.9218
i. Two Sided Confidence Limit Upper	336.55
j. Two Sided Confidence Limit Lower	3.64
k. One Sided Confidence Limit Upper	163.84
h. One Sided Confidence Limit Lower	4.44
e. Recommended Action	36

a. Item Part Number/CAGE	436A/28480
b. SPTE or GPTE	GPTE
c. Current Interval	36
d. Number of Items in Inventory	638
e. Percentage of Total Item in Interval	0.69%
d. Failure rate from P2 data (-lambda)	-0.004
e. Current Reliability	86.59%
f. Total Number of Items in P2 Report	66
g. Number OOT from P2	9
h. Total Time from P2 Report	2,255.5
h. Confidence Limit Reliability Target in AOP (R)	0.9218
i. Two Sided Confidence Limit Upper	78.23
j. Two Sided Confidence Limit Lower	23.39
k. One Sided Confidence Limit Upper	67.62
h. One Sided Confidence Limit Lower	25.86
e. Recommended Action	36

a. Item Part Number/CAGE	5245L/28480
b. SPTE or GPTE	GPTE
c. Current Interval	36
d. Number of Items in Inventory	611
e. Percentage of Total Item in Interval	0.66%
d. Failure rate from P2 data (-lambda)	-0.0045
e. Current Reliability	85.04%
f. Total Number of Items in P2 Report	33
g. Number OOT from P2	4
h. Total Time from P2 Report	897.0
h. Confidence Limit Reliability Target in AOP (R)	0.9218
i. Two Sided Confidence Limit Upper	106.92
j. Two Sided Confidence Limit Lower	15.96
k. One Sided Confidence Limit Upper	83.72
h. One Sided Confidence Limit Lower	18.27
e. Recommended Action	36

a. Item Part Number/CAGE	8482A/28480
b. SPTE or GPTE	GPTE
c. Current Interval	36
d. Number of Items in Inventory	609
e. Percentage of Total Item in Interval	0.66%
d. Failure rate from P2 data (-lambda)	-0.0002
e. Current Reliability	99.28%
f. Total Number of Items in P2 Report	139
g. Number OOT from P2	1
h. Total Time from P2 Report	5,184.0
h. Confidence Limit Reliability Target in AOP (R)	0.9218
i. Two Sided Confidence Limit Upper	16,459.03
j. Two Sided Confidence Limit Lower	177.96
k. One Sided Confidence Limit Upper	8,012.83
h. One Sided Confidence Limit Lower	217.04
e. Recommended Action	48

a. Item Part Number/CAGE	212159/07239
b. SPTE or GPTE	GPTE
c. Current Interval	36
d. Number of Items in Inventory	570
e. Percentage of Total Item in Interval	0.62%
d. Failure rate from P2 data (-lambda)	-0.0014
e. Current Reliability	95.08%
f. Total Number of Items in P2 Report	263
g. Number OOT from P2	11
h. Total Time from P2 Report	7,677.5
h. Confidence Limit Reliability Target in AOP (R)	0.9218
i. Two Sided Confidence Limit Upper	202.68
j. Two Sided Confidence Limit Lower	68.67
k. One Sided Confidence Limit Upper	178.09
h. One Sided Confidence Limit Lower	75.33
e. Recommended Action	48

a. Item Part Number/CAGE	2-10/93459
b. SPTE or GPTE	GPTE
c. Current Interval	36
d. Number of Items in Inventory	481
e. Percentage of Total Item in Interval	0.52%
d. Failure rate from P2 data (-lambda)	-0.0002
e. Current Reliability	99.28%
f. Total Number of Items in P2 Report	234
g. Number OOT from P2	2
h. Total Time from P2 Report	8,890.0
h. Confidence Limit Reliability Target in AOP (R)	0.9218
i. Two Sided Confidence Limit Upper	4,074.08
j. Two Sided Confidence Limit Lower	229.96
k. One Sided Confidence Limit Upper	2,722.34
h. One Sided Confidence Limit Lower	272.02
e. Recommended Action	48

a. Item Part Number/CAGE	6060AAN/89536
b. SPTE or GPTE	GPTE
c. Current Interval	36
d. Number of Items in Inventory	474
e. Percentage of Total Item in Interval	0.51%
d. Failure rate from P2 data (-lambda)	-0.0048
e. Current Reliability	84.13%
f. Total Number of Items in P2 Report	1668
g. Number OOT from P2	210
h. Total Time from P2 Report	43,653.5
h. Confidence Limit Reliability Target in AOP (R)	0.9218
i. Two Sided Confidence Limit Upper	38.07
j. Two Sided Confidence Limit Lower	30.19
k. One Sided Confidence Limit Upper	37.09
h. One Sided Confidence Limit Lower	30.93
e. Recommended Action	36

a. Item Part Number/CAGE	5328A/28480
b. SPTE or GPTE	GPTE
c. Current Interval	36
d. Number of Items in Inventory	448
e. Percentage of Total Item in Interval	0.48%
d. Failure rate from P2 data (-lambda)	-0.0022
e. Current Reliability	92.39%
f. Total Number of Items in P2 Report	61
g. Number OOT from P2	5
h. Total Time from P2 Report	2,260.5
h. Confidence Limit Reliability Target in AOP (R)	0.9218
i. Two Sided Confidence Limit Upper	186.85
j. Two Sided Confidence Limit Lower	35.02
k. One Sided Confidence Limit Upper	151.33
h. One Sided Confidence Limit Lower	39.69
e. Recommended Action	36

a. Item Part Number/CAGE	8552B/58480
b. SPTE or GPTE	GPTE
c. Current Interval	36
d. Number of Items in Inventory	436
e. Percentage of Total Item in Interval	0.47%
d. Failure rate from P2 data (-lambda)	-0.0017
e. Current Reliability	94.06%
f. Total Number of Items in P2 Report	36
g. Number OOT from P2	2
h. Total Time from P2 Report	1,198.0
h. Confidence Limit Reliability Target in AOP (R)	0.9218
i. Two Sided Confidence Limit Upper	549.01
j. Two Sided Confidence Limit Lower	30.99
k. One Sided Confidence Limit Upper	366.86
h. One Sided Confidence Limit Lower	36.66
e. Recommended Action	36

a. Item Part Number/CAGE	355C/28480
b. SPTE or GPTE	GPTE
c. Current Interval	36
d. Number of Items in Inventory	435
e. Percentage of Total Item in Interval	0.47%
d. Failure rate from P2 data (-lambda)	-0.0011
e. Current Reliability	96.12%
f. Total Number of Items in P2 Report	71
g. Number OOT from P2	3
h. Total Time from P2 Report	2,638.5
h. Confidence Limit Reliability Target in AOP (R)	0.9218
i. Two Sided Confidence Limit Upper	525.49
j. Two Sided Confidence Limit Lower	55.42
k. One Sided Confidence Limit Upper	389.90
h. One Sided Confidence Limit Lower	64.32
e. Recommended Action	48

a. Item Part Number/CAGE	2-20/93459
b. SPTE or GPTE	GPTE
c. Current Interval	36
d. Number of Items in Inventory	434
e. Percentage of Total Item in Interval	0.47%
d. Failure rate from P2 data (-lambda)	-0.0002
e. Current Reliability	99.28%
f. Total Number of Items in P2 Report	613
g. Number OOT from P2	5
h. Total Time from P2 Report	22,937.5
h. Confidence Limit Reliability Target in AOP (R)	0.9218
i. Two Sided Confidence Limit Upper	1,896.03
j. Two Sided Confidence Limit Lower	355.32
k. One Sided Confidence Limit Upper	1,535.59
h. One Sided Confidence Limit Lower	402.76
e. Recommended Action	48

a. Item Part Number/CAGE	P486A/28480
b. SPTE or GPTE	GPTE
c. Current Interval	36
d. Number of Items in Inventory	415
e. Percentage of Total Item in Interval	0.45%
d. Failure rate from P2 data (-lambda)	-0.0007
e. Current Reliability	97.51%
f. Total Number of Items in P2 Report	2268
g. Number OOT from P2	46
h. Total Time from P2 Report	66,427.5
h. Confidence Limit Reliability Target in AOP (R)	0.9218
i. Two Sided Confidence Limit Upper	305.24
j. Two Sided Confidence Limit Lower	183.93
k. One Sided Confidence Limit Upper	288.09
h. One Sided Confidence Limit Lower	193.27
e. Recommended Action	48

a. Item Part Number/CAGE	T58002105/45402
b. SPTE or GPTE	SPTE
c. Current Interval	36
d. Number of Items in Inventory	580
e. Percentage of Total Item in Interval	10.70%
d. Failure rate from P2 data (-lambda)	-0.0034
e. Current Reliability	88.48%
f. Total Number of Items in P2 Report	151
g. Number OOT from P2	9
h. Total Time from P2 Report	2,641.0
h. Confidence Limit Reliability Target in AOP (R)	0.9486
i. Two Sided Confidence Limit Upper	59.36
j. Two Sided Confidence Limit Lower	17.75
k. One Sided Confidence Limit Upper	51.31
h. One Sided Confidence Limit Lower	19.62
e. Recommended Action	36

a. Item Part Number/CAGE	KS2113/75245
b. SPTE or GPTE	SPTE
c. Current Interval	36
d. Number of Items in Inventory	291
e. Percentage of Total Item in Interval	5.37%
d. Failure rate from P2 data (-lambda)	-0.0003
e. Current Reliability	98.93%
f. Total Number of Items in P2 Report	159
g. Number OOT from P2	2
h. Total Time from P2 Report	5,847.0
h. Confidence Limit Reliability Target in AOP (R)	0.9486
i. Two Sided Confidence Limit Upper	1,736.45
j. Two Sided Confidence Limit Lower	98.01
k. One Sided Confidence Limit Upper	1,160.32
h. One Sided Confidence Limit Lower	115.94
e. Recommended Action	48

a. Item Part Number/CAGE	ANALM225/25500
b. SPTE or GPTE	SPTE
c. Current Interval	36
d. Number of Items in Inventory	284
e. Percentage of Total Item in Interval	5.24%
d. Failure rate from P2 data (-lambda)	-0.0016
e. Current Reliability	94.40%
f. Total Number of Items in P2 Report	373
g. Number OOT from P2	9
h. Total Time from P2 Report	5,495.5
h. Confidence Limit Reliability Target in AOP (R)	0.9486
i. Two Sided Confidence Limit Upper	123.52
j. Two Sided Confidence Limit Lower	36.93
k. One Sided Confidence Limit Upper	106.76
h. One Sided Confidence Limit Lower	40.83
e. Recommended Action	41

a. Item Part Number/CAGE	T58008106/45402
b. SPTE or GPTE	SPTE
c. Current Interval	36
d. Number of Items in Inventory	257
e. Percentage of Total Item in Interval	4.74%
d. Failure rate from P2 data (-lambda)	-0.0096
e. Current Reliability	70.78%
f. Total Number of Items in P2 Report	5251
g. Number OOT from P2	186
h. Total Time from P2 Report	19,329.5
h. Confidence Limit Reliability Target in AOP (R)	0.9486
i. Two Sided Confidence Limit Upper	12.43
j. Two Sided Confidence Limit Lower	9.71
k. One Sided Confidence Limit Upper	12.09
h. One Sided Confidence Limit Lower	9.96
e. Recommended Action	24

a. Item Part Number/CAGE	TTU378AE/26055
b. SPTE or GPTE	SPTE
c. Current Interval	36
d. Number of Items in Inventory	245
e. Percentage of Total Item in Interval	4.52%
d. Failure rate from P2 data (-lambda)	-0.0011
e. Current Reliability	96.12%
f. Total Number of Items in P2 Report	170
g. Number OOT from P2	3
h. Total Time from P2 Report	2,718.0
h. Confidence Limit Reliability Target in AOP (R)	0.9486
i. Two Sided Confidence Limit Upper	350.80
j. Two Sided Confidence Limit Lower	37.00
k. One Sided Confidence Limit Upper	260.28
h. One Sided Confidence Limit Lower	42.94
e. Recommended Action	43

a. Item Part Number/CAGE	361046001/26055
b. SPTE or GPTE	SPTE
c. Current Interval	36
d. Number of Items in Inventory	216
e. Percentage of Total Item in Interval	3.98%
d. Failure rate from P2 data (-lambda)	-0.0052
e. Current Reliability	82.93%
f. Total Number of Items in P2 Report	90
g. Number OOT from P2	8
h. Total Time from P2 Report	1,539.5
h. Confidence Limit Reliability Target in AOP (R)	0.9486
i. Two Sided Confidence Limit Upper	40.81
j. Two Sided Confidence Limit Lower	11.26
k. One Sided Confidence Limit Upper	34.89
h. One Sided Confidence Limit Lower	12.50
e. Recommended Action	36

a. Item Part Number/CAGE	TTU27E/05808
b. SPTE or GPTE	SPTE
c. Current Interval	36
d. Number of Items in Inventory	189
e. Percentage of Total Item in Interval	3.49%
d. Failure rate from P2 data (-lambda)	-0.0021
e. Current Reliability	92.72%
f. Total Number of Items in P2 Report	25
g. Number OOT from P2	1
h. Total Time from P2 Report	485.0
h. Confidence Limit Reliability Target in AOP (R)	0.9486
i. Two Sided Confidence Limit Upper	997.89
j. Two Sided Confidence Limit Lower	10.79
k. One Sided Confidence Limit Upper	485.81
h. One Sided Confidence Limit Lower	13.16
e. Recommended Action	36

a. Item Part Number/CAGE	7310/99866
b. SPTE or GPTE	SPTE
c. Current Interval	36
d. Number of Items in Inventory	163
e. Percentage of Total Item in Interval	3.01%
d. Failure rate from P2 data (-lambda)	-0.0003
e. Current Reliability	98.93%
f. Total Number of Items in P2 Report	302
g. Number OOT from P2	1
h. Total Time from P2 Report	3,654.0
h. Confidence Limit Reliability Target in AOP (R)	0.9486
i. Two Sided Confidence Limit Upper	7,518.14
j. Two Sided Confidence Limit Lower	81.29
k. One Sided Confidence Limit Upper	3,660.09
h. One Sided Confidence Limit Lower	99.14
e. Recommended Action	48

a. Item Part Number/CAGE	65A1J/30760
b. SPTE or GPTE	SPTE
c. Current Interval	36
d. Number of Items in Inventory	157
e. Percentage of Total Item in Interval	2.90%
d. Failure rate from P2 data (-lambda)	-0.0013
e. Current Reliability	95.43%
f. Total Number of Items in P2 Report	65
g. Number OOT from P2	2
h. Total Time from P2 Report	1,563.0
h. Confidence Limit Reliability Target in AOP (R)	0.9486
i. Two Sided Confidence Limit Upper	464.18
j. Two Sided Confidence Limit Lower	26.20
k. One Sided Confidence Limit Upper	310.17
h. One Sided Confidence Limit Lower	30.99
e. Recommended Action	36

a. Item Part Number/CAGE	4177B/99866
b. SPTE or GPTE	SPTE
c. Current Interval	36
d. Number of Items in Inventory	155
e. Percentage of Total Item in Interval	2.86%
d. Failure rate from P2 data (-lambda)	-0.0005
e. Current Reliability	98.22%
f. Total Number of Items in P2 Report	54
g. Number OOT from P2	1
h. Total Time from P2 Report	1,836.0
h. Confidence Limit Reliability Target in AOP (R)	0.9486
i. Two Sided Confidence Limit Upper	3,777.59
j. Two Sided Confidence Limit Lower	40.85
k. One Sided Confidence Limit Upper	1,839.06
h. One Sided Confidence Limit Lower	49.81
e. Recommended Action	48

LIST OF REFERENCES

Akiyama, K., (1995). *"The Current Process of Changing Intervals,"* Technical Report, Naval Warfare Assessment Division, May 1995.

Department of the Navy, Chief of Naval Operations (1996). OPNAVINST 4790.2F, *Naval Aviation Maintenance Program*, Volume III.

Department of the Navy, Commander Naval Air Systems Command, Letter Ser 00/0651 to the Chief of Naval Operations. Subject: Assessment of Cost Effectiveness of Increasing Aircraft Mission Capability Through Improved Reliability and Maintainability, 11 May 1983.

Department of the Navy, Metrology and Calibration Program (1983). NAVAIR 17-35TR-1, Technical Requirements for Calibration of Test and Monitoring Systems (TAMS), October 1983.

Department of the Navy, Metrology and Calibration Program (1986). NAVAIR 17-35TR-5, *Technical Requirements for Calibration Interval Establishment for Test and Monitoring Systems (TAMS)*, January 1986.

Dwyer, S., Head Research Analyst, Naval Warfare Assessment Division. Personal Interview with LCDR Albright, 14 August 1997.

Dwyer, S., (1992). *"A Case for Reliability Enhancement,"* Technical Report, Naval Warfare Assessment Division, July 1992.

Freydoz, M., Inspector, Federal Aviation Administration. Personal Interview with LCDR Albright, 8 August 1997.

Goldfinger, J., Instructor, Naval Aviation Safety School. Electronic Mail to LCDR Albright, 12 September 1997.

Kang, K., (1993). *Spreadsheet Decision Support Model for Aviation Logistics*, Technical Report, U.S. Naval Postgraduate School, Monterey, California, November 1993.

Lout, D., Naval Air Logistics Database Analyst, Naval Air Systems Command. Electronic Mail to LCDR Albright, 14 October 1997.

Skinner, C., Maintenance Supervisor, Federal Express. Personal Interview with LCDR Albright, 8 August 1997.

Vazsonyi, A., (1993). "Where Spreadsheets Ought to be Going: The Potential of Spreadsheets," *Interfaces* 23: 26-39.

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